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Malaria in Bombay, 1928

BY

MAJOR G. COVELL,
M.D. (Lond.), D.T.M. & H. (Eng.), F.E.S., I.M.S.,
Assistant Director, Malaria Survey of India
(on special duty with the Government of Bombay)

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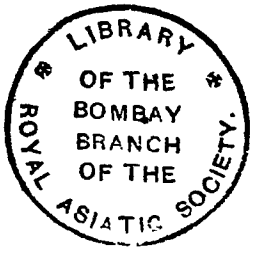

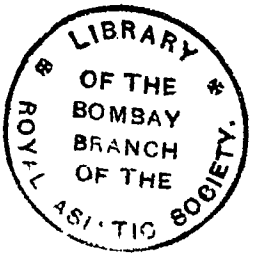

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PREFACE

THE inquiry into malarial conditions in Bombay which forms the subject of this report was carried out during the period March 20th to September 21st, 1928. In presenting the report I wish to convey my grateful thanks to the following gentlemen for their assistance during the investigation :—

The President and Members of the Malaria Advisory Committee.

Dr. J. E. Sandilands, Executive Health Officer, Bombay.

Dr. J. S. Nerurkar, Assistant to the Executive Health Officer (Malaria), and the staff of the Malaria Department, whose services were placed at my disposal whenever they were required; and especially to Captain G. G. Limaye, whose assistance in recording the data of the Spleen Census of School Children was most valuable.

The Municipal School Medical Inspectors, who arranged the programme for the Spleen Census.

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Dr. P. A. Dalal, Medical Officer of the E. D. Sassoon group of mills.

Mr. J. D. Pember, Superintending Engineer, and Mr. W. F. Webb, Deputy Superintending Engineer of the E. D. Sassoon group of mills.

Mr. A. Hale White, Executive Engineer, General Works, Bombay Port Trust.

Mr. J. A. Jones, Chief Engineer, B. B. & C. I. Railway.

Major S. B. Mehta, Officiating Police Surgeon, Bombay.

Mr. J. F. Gennings, Director of Information and Labour Intelligence.

Mr. S. K. Banerji, Meteorologist, Bombay.

Mr. W. Dillon, Acting Collector, Bombay.

I also wish to thank Sub-Assistant Surgeon Subedar J. D. Baily, I.M.D., and Sub-Assistant Surgeon Jemadar Abdul Majid, I.M.D., of the Malaria Survey of India, who assisted me during the first 1½ months and last 4½ months of the inquiry respectively.

BOMBAY: G. COVELL.
September 21st, 1928.

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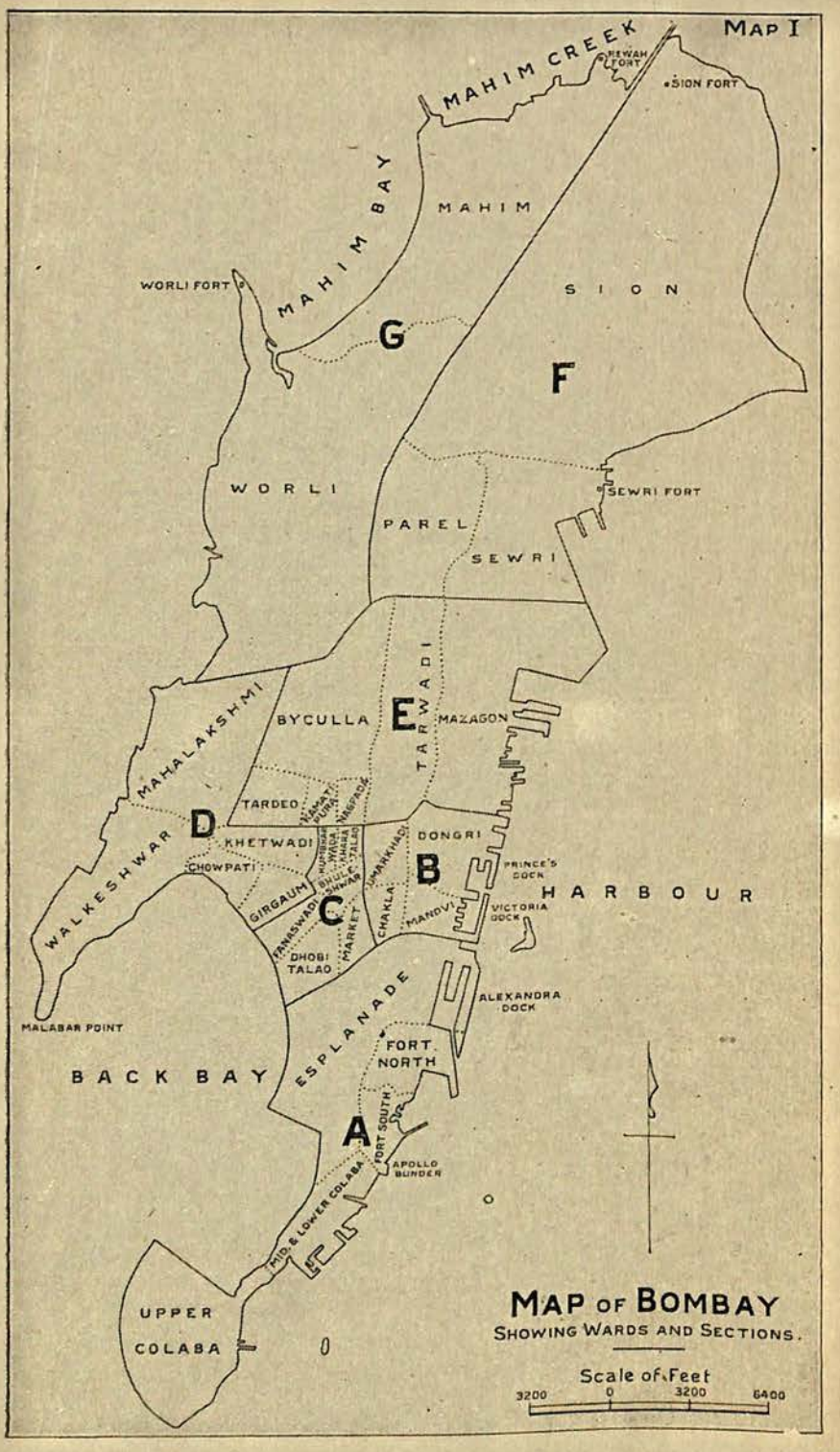


Frontispiece

CHAPTER I

INTRODUCTION

Brief Description of Bombay

The City of Bombay, the capital of the Bombay Presidency and the principal seaport of Western India, is situated on the shore of the Arabian Sea, in 18° 55′ N. and 72° 54′ E. The land upon which the City has been built originally consisted of a group of seven small islands, which have been united to one another by means of causeways and breakwaters, forming the so-called Island of Bombay. This is really a misnomer, as it is now connected by causeways and railway embankments with the larger island of Salsette, which is itself linked by similar means with the mainland.

The Island of Bombay covers an area of some 24 square miles, and consists of a low-lying plain, about 11½ miles long by 3 to 4 miles broad, flanked by two ranges of low broken hills. To the south these two ranges are represented respectively by the promontories of Malabar Hill and Colaba Point, which jut into the sea and partly enclose a large shallow expanse of water known as Back Bay.

The hills on the island are all small, reaching on an average an elevation of little more than 150 feet. There are no rivers or permanent natural streams ; but certain parts of the island, particularly the central and northern portions, are subject to temporary flooding during the rainy season.

During the past 150 years many changes have been brought about by the filling in of low-lying land and the reclamation of foreshore. At the present time there remain in the island 136 acres of low-lying land, of which 72 acres, situated for the most part in the neighbourhood of Mahalakshmi racecourse, are below mean sea level.

There is no forest or jungle and but little natural undergrowth on the island. The area under cultivation has progressively decreased during recent years, and is confined to the northern half of the island. At the present time about 400 acres are covered with toddy palms, whilst grass farms and ricefields combined occupy some 250 acres in all.

Climate

The climate of Bombay is warm, equable and humid. The average mean annual temperature is approximately 80° Fah., January being the coldest month with an average mean temperature of 74°, and May the warmest with an average mean temperature of 85°. The wet season usually begins in June when the monsoon bursts, and continues until the middle or end of October. After the onset of the rains the temperature falls slightly, but remains remarkably uniform, almost within 1° of the mean of the year, until October when a slight rise

occurs. From October the temperature falls gradually until January, after which it rises again to the maximum in May.

The amount of the annual rainfall shows considerable fluctuation, the average being 71 inches. The maximum fall recorded in one year is 114 inches, and the minimum 33 inches. There are remarkable local variations in the amount of rainfall, *e.g.*, in the present monsoon 30 more inches have been recorded in the Fort than at Colaba.

The atmosphere is generally moist, the lowest relative humidity, 67 per cent., occurring late in December. During December, January and February it remains fairly uniform, but from then onwards it gradually increases. With the fall of temperature which occurs in June after the onset of the rains the relative humidity increases, and the maximum, 87 per cent., is reached about the middle of July. From then till September there is little fluctuation, but about the middle of October a somewhat sharp fall occurs. The diurnal variation in the relative humidity is most marked in the dry season. In December, when at 2 p.m. the humidity is only 55 per cent., at 6 a.m. it is 67 per cent., but in July the respective figures are 84 and 90.

The prevailing winds vary according to season. During the monsoon months the wind blows from the W.S.W. The maximum velocity is 18·8 miles per hour, and is attained in July. By November the prevailing winds come from the N.E., but from January onwards the easterly component gradually disappears, and is replaced in March by a westerly one. About the middle of May the northerly component is replaced by a southerly one, and from then onwards south-westerly winds increase in strength to their maximum in July.

Various climatic data for a number of years will be found in Appendix A.

Population

At the Census of 1921 the population of Bombay was given as 11,75,914. Its composition is peculiar, a considerable proportion of the inhabitants being made up of persons of the labouring class who visit Bombay in search of employment during the dry season. There are in addition people who come to the City for business or other purposes, remaining for a year or more, whilst a third category is made up of visitors for short periods, travellers by rail or steamer who are constantly arriving and departing, the crews of vessels in the harbour, and pilgrims who pass through on their way to Mecca.

In 1906 rather more than four-fifths of the total population were concentrated in the southern half of the island. Since then the proportion has shifted considerably, the number of persons living in F and G Wards having almost doubled; but the latest figures available show that even now 70 per cent. of the inhabitants live in Wards A, B, C, D and E, which comprise rather less than half the total area of the island. Figures showing the density per acre of population in the various Sections of the island in 1906 and 1921, the population of the different Sections in 1906 and 1921, and the estimated population in 1927 are given in Appendix B.

The following Table, compiled from the Census returns for 1921, indicates the various places from which the population of Bombay is derived :—

Birth-places	Numbers
Bombay City	1,87,652
Bombay Presidency, other than above..	7,64,350
Other parts of India	2,03,785
Other Asiatic Countries	8,891
Europe	10,334
Africa	462
All other Countries	440
Total	11,75,914

Out of the total population, those born in Bombay formed 16 per cent., those born in other parts of the Bombay Presidency 65 per cent. and those born elsewhere 19 per cent. Of those born in the Presidency excluding Bombay City, nearly one-third came from Ratnagiri District.

The percentage distribution of the population of Bombay by religion, compiled from the Census figures from 1872 to 1921 is shown below :—

Religion	1872	1881	1891	1901	1911	1921
Hindu	63·3	65·2	66·1	65·5	67·8	71·2
Mohamedan	21·6	20·5	18·9	20·1	18·3	15·7
Christian	5·4	5·5	5·5	5·8	5·8	5·8
Parsee	6·8	6·2	5·8	6·0	5·2	4·5
Jain	2·3	2·2	3·1	1·8	2·1	2·0
Jew	0·5	0·4	0·6	0·8	0·7	0·6
Others	0·1	..	..	..	0·1	0·2

It will be noticed that the percentage of Hindus has shown a steady increase, that of the Mohamedans and Parsees has decreased, whilst the proportion of the other denominations has remained remarkably constant.

Occupation

The Cotton Mills afford the principal source of employment in Bombay. The industry dates from the year 1854, when the first spinning factory was inaugurated. By 1905 the total number of mills in operation was 82. This figure remained the same in 1925, as although nine more mills had been erected in the interval an equal number had for various reasons been closed down.

At the 1921 Census 7,16,969 persons in Bombay were returned as workers, and 4,59,945 as dependents. Of the workers a total of 3,03,777 were returned under the head of " Industries, " of whom 1,59,690 were classed as textile operators. The number of hands employed in the cotton mill industry in 1921 was 1,46,000.

Wages

The average daily earnings of the mill-hands in 1923 were stated to be as follows :—

	Rs.	a.	p.
Men	1	7	5
Women	0	12	5
Children	0	12	3

As regards other occupations, coolies employed in heavy work receive Rs. 1-2 to Rs. 1-4 per day, sweepers Rs. 19 to Rs. 23 per month, skilled workmen such as masons and carpenters Rs. 60 to Rs. 90, boatmen Rs. 20 to Rs. 25, office peons, chowkidars and messengers Rs. 23 to Rs. 25. Clerks receive Rs. 50 to Rs. 75, and the more highly paid Rs. 110 to Rs. 160.

Price of Food

As was pointed out by Bentley, fluctuations in the price of food-stuffs involve very serious hardships to the poverty-stricken lower classes. The average prices of the four principal food-grains used in Bombay during the last 16 years are given in Appendix C.

The prices of grain remained fairly constant from 1912 to 1918, when there was a sudden rise. The famine of 1918-1919 was one of the most extensive and severe on record, and it was followed by another in 1920-1921 which though not so widespread was very serious. There has been a slight recovery during recent years, but the prices of food-stuffs are still very much higher than they were at the time of Bentley's inquiry. On the other hand, wages have likewise greatly increased and it seems probable that they have at least kept pace with the increase in the price of food.

Cost of Living

In 1921 an inquiry was held by the Bombay Labour Office into various points connected with the cost of living among the working classes. The results were based on the examination of 2,473 family budgets. In the case of the families dealt with, the average monthly income of the family was Rs. 52-4-6, and the percentage expenditure on the various items was as follows :—

Food	56·8
Fuel and Lighting	7·4
Clothing	9·6
House Rent	7·7
Miscellaneous Expenditure	18·5
	100·0

It was found that 47 per cent. of the families were in debt to money-lenders, the average indebtedness extending to an equivalent of

2½ months' earnings. The usual charge of the money-lenders was 75 per cent. per annum, but in some cases this was greatly exceeded.

There is no doubt that a very large proportion of the working classes, who form the majority of the inhabitants of Bombay, exist under conditions of great poverty.

Overcrowding

This has been a very serious problem in Bombay for many years, but it was not until the outbreak of bubonic plague in 1896 that serious efforts were made to relieve the congestion. The Bombay City Improvement Trust was created in 1898 for the work of making new streets, opening out crowded localities, reclaiming lands from the sea, and constructing sanitary dwellings for the poor and for the Police.

By 1920 the Improvement Trust had provided 21,387 new tenements as against 24,428 tenements demolished, and the Municipality had provided 2,900 tenements for its staff.

However, the work of the Improvement Trust and Municipality failed to keep pace with the requirements of the City. In the report of the Labour Office inquiry above referred to it was stated that 99 per cent. of the working class families lived in single rooms, the average number of persons per one-roomed tenement being 4·03. According to the Census figures of 1921 there were at that time in Bombay no less than 135 instances in which a single room was occupied by six families or more.

In order to cope with this situation, a scheme was evolved with the object of providing 50,000 one-roomed tenements for between 200,000 and 250,000 people.

The tenement buildings erected by the Improvement Trust, Municipality, Port Trust and other public bodies are constructed on sanitary lines, and are usually well lighted and well ventilated. Most of the modern buildings are of reinforced concrete.

Unfortunately, these buildings do not appear to be favoured by the people for whose benefit they have been erected, who prefer to live in their present overcrowded and insanitary surroundings. Hence, whilst overcrowding is present to an almost incredible extent in certain quarters of the City, where there resides a population the density of which exceeds 700 per acre, there are in the more northern part of the island vast blocks of tenements as yet unoccupied.

Water Supply

Until 1866 this was drawn from wells only. Since that date four lakes have been constructed outside municipal limits and connected to the City by means of pipes. The largest of these is Tansa, which contains 35,000 million gallons of water at the end of the rainy season. The construction of the last line of pipes has now been completed, and the average daily supply per head of population at the present time is 50 gallons.

Vital Statistics

As was pointed out by Bentley, the peculiar features of the population of Bombay render any deductions based upon the mortality rates of the City of but little value. The chief source of fallacy is supplied by the extraordinary fluctuations of the population alluded to above. Bentley estimated that the influx of people during the dry season and their subsequent exodus before the rains affected on the average from 15 to 25 per cent. of the population present at the Census, which is taken at about the end of March. He further pointed out that this influx and exodus is not by any means constant from year to year, depending as it does on the varying economic conditions and demand for labour in the City and agricultural districts respectively.

At first sight it seems strange that such large numbers of cultivators can leave their fields for so long a period of each year. The reason is that in Ratnagiri District, from which most of them come, there is only one crop during the year, for during the remaining period scarcity of rain prevents the raising of a second.

Infantile Mortality

The figures representing the infantile mortality in Bombay would suggest that this is excessively high, the average for the years 1921 to 1925 being 447 per 1,000 of recorded births. As has been pointed out by the Executive Health Officer, this figure is certainly much too high, owing to the fact that the number of births registered does not represent the actual numbers of infants in the City. Many of the women return to their native villages for the birth of their children; whilst a considerable number of births occurring in the City itself are not registered.

Even so, the actual mortality is very high, and is considerably greater than that of the Presidency as a whole. Overcrowding is no doubt one of the chief contributing causes, and it has been shown that in Bombay the proportion of deaths to births varies inversely as the number of rooms occupied by the parents. In addition to this, the Executive Health Officer in his report for 1926 attributed the high rate in a great measure to the effects of malaria, which is a recognised cause of high infantile mortality wherever the disease is prevalent in a marked degree.

Causes of Death

Reference to the Annual Reports of the Executive Health Officer for the past ten years shows that Diseases of the Respiratory System cause the highest death-rate, the average of the years 1916 to 1925 being 14·85 per 1,000 of the population. Congenital Debility and Diseases of Early Infancy constitute the next most fatal group, whilst Malaria and "Ague and Remittent Fever" occupy the third place, with a combined rate of just over three per thousand.

Further information on the subjects dealt with in this chapter will be found in the works mentioned in the *List of References to Literature*, Nos. 4, 14, 15 and 28.

CHAPTER II

THE HISTORY OF MALARIA IN BOMBAY

Malaria in Bombay prior to Bentley's Investigation

It is probable that malaria has been prevalent in Bombay from very early times. A number of references were cited by Bentley dating from the year 1673 onwards, in which allusion was frequently made to the unhealthiness of the island and to the prevalence of fevers.

It was in Bombay, in 1887, that Vandyke Carter, the first medical man in India to confirm Laveran's discovery of the malaria parasite, recorded positive results in the blood of 13 per cent. of the cases of "malarious fever" which he examined. As Bentley remarked, this figure represents only a small proportion of the cases actually harbouring parasites, as Carter only noted the presence of pigmented organisms.

By the year 1901 it was generally recognized that malarial fever was the cause of a very large percentage of the sickness in the City, and in that year a committee consisting of 11 members of the Corporation was appointed to deal with the question of the presence of Anopheline mosquitoes in Bombay. No investigation regarding the prevalence of malaria was undertaken, but the committee recommended that steps should be taken to destroy all kinds of mosquitoes.

In 1903 the Police Surgeon, Dr. S. A. Powell, read a paper before the Bombay Medical and Physical Society, giving the results of the microscopic examination of the blood of 3,413 cases of fever in Bombay, chiefly among the City Police. Amongst these he found malaria parasites in 2,542 instances.

In 1906 a committee comprising representatives of the Government Medical Service, Sanitary Service and "mosquito experts," members of the Corporation and medical men, was appointed to inquire into the causation and spread of malarial and other fevers in the City. This committee sat from 1906 to 1908, and issued a report in which great stress was laid upon the importance of plague, but little mention was made of malaria.

Towards the end of 1907, however, complaints began to be made about malaria in the neighbourhood of Frere Road in Fort North Section, and there were also 40 cases of malaria reported among 200 members of the Governor's bodyguard, who were quartered in the lines at Chowpati, at the base of Malabar Hill.

During the year 1908 malaria in Bombay was very severe, Wards A and B suffering the most seriously, especially the Section of Fort North in the former Ward. In November of that year Captain W. G. Liston, I.M.S., published a most important paper in the Journal of the Bombay Natural History Society, recording the results of an investigation carried out by himself and Captain F. P. Mackie, I.M.S., in the neighbourhood

of Frere Road, adjoining the New Docks (Alexandra Dock). He recorded that 80 per cent. of the children resident in that locality examined by him showed enlargement of the spleen, and that 50 per cent. were found to have malaria parasites in their blood. His most important observation, however, was the fact that 25 per cent. of the specimens of *Anopheles stephensi* dissected by him were found to harbour the parasites of malaria. This was the first occasion on which this species had been found infected in nature, and the discovery afforded the clue to the causation and distribution of malaria in Bombay.

Early in 1909 Captain A. G. McKendrick, I.M.S., was appointed as a special officer to investigate the cause of the outbreak of malaria in the City; and a committee consisting of representatives from the Municipal Corporation, the Bombay Port Trust, the City of Bombay Improvement Trust, the G. I. P. Railway and the B. B. & C. I. Railway was formed for the purpose of carrying out any measures which might appear necessary for the immediate mitigation of malaria.

Captain McKendrick commenced his investigation, and examined more than 8,000 children in various parts of the City for splenic enlargement. This officer was, however, recalled to duty at Coonoor in May 1909 and the conduct of the investigation was taken over by Dr. C. A. Bentley. The latter carried out a systematic malaria survey of the City during the next two years, and in April 1911 submitted his classical "*Report of an Investigation into the Causes of Malaria in Bombay, and the Measures necessary for its Control.*"

Brief Summary of Bentley's Report

The following are some of the principal findings of the report:—

(*a*) *Conclusions.*

(*i*) Whilst the Island of Bombay is not, taken as a whole, very malarious, there are great differences in the incidence of the disease in various localities. In the northern part of the island, which is undrained and subject to flooding in the monsoon, the spleen index approximates zero*; in the centre, though a little higher, it is still very low; it is only in the southern portion of the island that it shows a considerable rise.

(*ii*) The areas most affected are Esplanade, Fort North and Mandvi Sections. There is in Fort North an area which has been adversely affected by proximity to the New Dock works, but over and above this there is another and much larger area which is seriously affected by a similar cause to that giving rise to a serious amount of malaria in Dhobi Talao, *i.e.*, the existence of hundreds of private house wells breeding malaria-carrying mosquitoes.

(*iii*) The mosquito carrier of the disease in Bombay is *Anopheles stephensi*. The permanent breeding-places of this mosquito are chiefly wells, cisterns, fountains, and garden and other tanks. Sixty-five

*I have heard it stated recently in Bombay that Bentley did not investigate malarial conditions in the north of the island. This is not correct; on the contrary, he did so with particular care, and examined no less than 8,409 children in Wards F and G for splenic enlargement.

per cent. of the total number of larvæ of this species found in Bombay were in wells, the most favourable breeding-places being those situated within houses. Where there are many wells there is much malaria; where there are few there is little malaria, unless other special breeding-places exist in large numbers; and where there are no wells malaria is usually reduced to a minimum. Temporary pools and collections of water only appear to be infected when permanent breeding-places of *A. stephensi* exist in the neighbourhood.

(*iv*) The highest infection rate among Anophelines was encountered during the period July to October. The highest sporozoite rate was met with in July 1910 during a three weeks' break in the rains.

(*v*) The incidence of malaria among the population begins to rise in the latter half of July, and reaches its height during the months of September, October and November.

(*vi*) There is no relationship between the annual amount of rainfall and the incidence of malaria. On the other hand, the latter is affected by the distribution of the rainfall, breaks in the rains being favourable to the disease. The most malarious season in Bombay coincides with the period of highest and most uniform atmospheric humidity.

(*vii*) As regards the origin of the epidemic of 1908, the existence of unrecognised centres of malarial infection in various parts of the City, and a gradual and suspected increase of malaria in association with these centres was the primary cause of the outbreak, and the determining factor was a combination of climatic, economic and other conditions favourable to the spread of malaria.

(*viii*) Imported malaria is not an important factor in Bombay; the amount of malaria contracted locally is many times in excess of that introduced from without.

(*ix*) The continued presence of malaria is not due to the habits of the ignorant masses of the population, but to causes for the most part within the control of the educated and wealthy property-owning classes of the community. It is among the very classes who, if they chose to do so, could eradicate autochthonous malaria from the greater part of the City within a year, that opposition has been chiefly met with.

(*b*) *Recommendations.*

(*i*) A Special Department should be created to be engaged solely in mosquito destruction, under a responsible officer. The appointment of such an officer is the most important part of the whole scheme. *It is absolutely essential that one responsible official shall be able to devote his whole time and attention to perfecting the details of the work, and seeing that it is properly carried out.*

(*ii*) The present law is entirely inadequate to deal with malaria prevention; until an enactment is passed laying down clearly and inclusively that the breeding of mosquitoes in any and every collection of water is a breach of the law, and giving power to the sanitary authorities themselves to abate such nuisances, it is difficult to see how mosquito breeding is to be prevented in Bombay.

(*iii*) As regards breeding-places :—

(*a*) The construction of new open wells, uncovered cisterns, fountains or tanks to be prohibited.

(*b*) Open or temporarily closed wells, cisterns, fountains, tanks, garden tubs, barrels and vessels for storing water to be registered and licensed.

(*c*) Wells to be registered and either

(1) filled up, or

(2) permanently covered, with a pump if desired, or

(3) licensed, covered over with or without a trap-door, stocked with fish and periodically inspected, or

(4) in the case of wells situated not less than 50 feet from a dwelling-place, licensed, kept stocked with fish, free from weed and periodically inspected.

(*d*) Cisterns to be rendered mosquito-proof.

(*e*) Large tanks to be kept free from weed, stocked with fish or treated with oil. If still found breeding, to be filled in.

(*f*) Garden tanks and fountains to be stocked with fish or completely emptied at fixed intervals. Failing this, to be filled in.

(*g*) Garden tubs to be covered, not fixed or sunk in the earth ; if found breeding, to be removed.

(*h*) Large yards and compounds, open spaces and vacant building plots to be properly drained and levelled. Collections of machinery to be stacked in such a way that they will not allow opportunities for breeding. Owners of empty tins, etc., to be compelled to take due precautions, failure to comply with which should entail a penalty.

Special measures were also advocated in the case of certain specifically mentioned breeding-places.

Bentley concluded his report with the following remarks :—" The problem of malaria prevention in the City is far more easy, as far as natural difficulties are concerned, than that to be faced in many other places ; not only can malaria be reduced, but it can be absolutely eradicated from the greater part of Bombay ; and the expenditure required is not only well within the means of the City, but would amount to less than a tenth part of the loss occasioned each year by the disease."

The History of Malaria in Bombay since 1911

As the result of Bentley's recommendations a Special Malaria Department was created in April 1912, and Dr. K. B. Shroff was placed in charge as Special Assistant to the Executive Health Officer for Malaria. Bentley had proposed a scheme for the abolition of malaria-carrying mosquitoes in A, B, C, D and E Wards only, for which he considered the following staff necessary :—5 Inspectors, 50 Sub-Inspectors and 150 coolies, with 7 Sub-Inspectors and 35 coolies as well-gangs, and 3 Sub-Inspectors and 12 coolies as fish-gangs. The staff appointed in 1912 consisted of 5 Inspectors, 38 Sub-Inspectors, 76 coolies

and 4 muccadams. Anti-malarial action was restricted to A, B, C, D and E Wards, each Ward being in charge of one Inspector.

In 1914 the services of one of the Inspectors and of 5 Sub-Inspectors were dispensed with, and in the following year 5 more Sub-Inspectors were discharged. In 1918 the Special Malaria Department was disbanded, and the staff, which had dwindled to 2 Inspectors, 17 Sub-Inspectors and 34 coolies, was distributed amongst the 7 Deputy Health Officers. During the period in which the Department was in existence the incidence of malaria in Bombay was greatly diminished, in spite of a very considerable amount of apathy and even active opposition encountered by the staff in the execution of their duties.

As was to be expected, the abolition of the Department turned out to be a short-sighted piece of false economy. The meagre staff remaining naturally proved entirely inadequate to cope with the work of inspection of wells, cisterns, etc., and in numerous instances the covers and trap-doors were removed or allowed to get into disrepair, whilst in other cases wells which had been hermetically covered were re-opened.

The incidence of malaria again began to increase, and in June 1922 the heads of about 40 commercial houses in the Fort area sent in a petition to the Corporation, drawing their attention to the serious increase of the disease in their neighbourhood. Complaints of malaria among the staff of St. George's Hospital, who had suffered very severely from the disease in the 1908 outbreak, were again received, and it was even stated that one of the principal reasons for the suggested removal of this institution to another site was the amount of malaria existing in its vicinity.

In 1923 the Special Malaria Department was reconstituted, with the same numbers of staff as had been originally appointed in 1912. Dr. Shroff was again put in charge. As was natural, a very large proportion of the work which had previously been accomplished had to be commenced over again.

In the same year, as the result of the occurrence of outbreaks of malaria amongst the crews of ships leaving Bombay in the autumn of 1922, Lieut.-Colonel S. R. Christophers, I.M.S., was asked to investigate the circumstances under which such outbreaks occurred. In his report he gave it as his opinion that the most probable cause was the breeding of Anopheline mosquitoes in the cisterns on the roof of St. George's Hospital and other large buildings in the area adjoining the Docks. He drew special attention to the importance of dealing with wells and cisterns in the City, and also to the suitability of modern constructional works to the needs of the Bombay Anophelines, and laid great stress on the urgent need for providing adequate legal powers to deal with mosquito breeding.

In 1924 malaria was again very prevalent in Bombay, and a number of cases once more occurred amongst the crews of ships in the Docks. The Port Health Officer, Lieut.-Colonel W. Houston, I.M.S., investigated these outbreaks, and submitted a report in which he pointed out that

on this occasion the cisterns on St. George's Hospital could not be blamed, as they had been kept under careful supervision. He considered the outbreaks to be due to the diffusion of infected mosquitoes from the houses situated to the south-west of the Docks, in which malaria was very rife, and pointed out that the prevailing wind in the monsoon blew directly from this situation on to the ships infected.

In January 1925 a Note was issued by the Executive Health Officer on the subject of malaria in the City, in which he pointed out that the complete scheme advocated by Bentley had never in fact been given a fair trial, and urged that the malaria staff should be largely increased. He also laid stress on the inadequacy of the existing laws, and of the fines inflicted for their contravention, the need for a satisfactory scheme of drainage, and the importance of unity of control and co-operation in carrying out anti-malarial measures. In connection with the last of these he recommended that, failing the appointment of one officer endowed with adequate powers for effective action in every part of the City, a Central Anti-malarial Committee should be appointed, containing members nominated to represent the various authorities which control different areas in the island, such as the Port Trust Authority, Military Authorities and Railways.

The Government of Bombay decided to appoint this committee, which held its first meeting on 23rd February 1926. Sanction was also given for an increase of the staff of the Malaria Department, the budget strength of which is now as follows :—

Inspectors	7
Sub-Inspectors	85
Muccadams	9
Coolies	220
Carpenters	2
Masons	2

In Appendix D will be found tables showing the number of malaria cases treated annually at Municipal Dispensaries, the number of malaria admissions in different institutions, the number of deaths recorded annually as due to "malaria, ague and remittent fever," and the number of cases per thousand of strength treated annually amongst the troops stationed in Bombay and the City Police, for a number of years.

The last set of figures probably gives the best indication of the amount of malaria in the City. The Police are a picked body of men of good physique, well-fed, well-clothed and well-housed, and receive regular medical attention. A reference to the Appendix shows that during the years 1921 to 1927 the average number of attacks of malaria recorded amongst them per annum was 1,162 per 1,000 of strength. At the time of Bentley's investigation the figure was only about 500 per 1,000 of strength.

Taking all the available evidence into consideration, and making due allowance for possible inaccuracies in the figures, it appears that the history of malarial incidence in Bombay since the year 1911 has been

as follows: There was at first a diminution of malaria, due in a large measure to a reduction of the permanent breeding-places of *Anopheles stephensi* as a result of the activities of the Malaria Department. Following the abolition of the Department in 1918 there was a marked increase in the incidence of the disease, which continued unchecked until the end of 1925. During the last two years there has been an appreciable diminution in malarial incidence, but in the last published report of the Executive Health Officer it is stated that the returns afford an indication that malaria is widely prevalent in the City, and that it is probable that the disease plays an important part in the production of the very high infantile mortality in Bombay.

As will be seen from the following chapters, malaria has become very much more widely diffused in the island during the last few years, and it is probable that the disease as a whole is now more prevalent in Bombay than was the case at the time of Bentley's investigation.

Outbreaks of Malaria due to "Aggregation of Labour" in Bombay

Serious outbreaks of the disease in connection with the construction of railways, dockyards, canals and other enterprises involving the employment of large numbers of labourers form a well-recognised feature of malaria throughout the tropics. In Bombay epidemics from this cause have occurred from time to time. Bentley records the occurrence of such outbreaks in connection with the construction of the Colaba Causeway (1828-41), various reclamation schemes carried out in 1861-66, and in later times the construction of the water works at Malabar Hill and Bhandarwada Hill, and of the Alexandra Dock and Hughes Dry Dock. He noted on the other hand that there were no such outbreaks of the disease in connection with the construction of Prince's and Victoria Docks, or with the more recent work undertaken during the construction of the Port Trust Railway and the reclamation operations at Sewri. He attributed this to the facts that (*i*) no serious centres of malarial infection existed in the vicinity of these works, (*ii*) few permanent breeding-places of dangerous species of Anophelines were present in the neighbourhood and (*iii*) the labourers employed were not, in the case of the Dock works, encamped on the site of the works.

In the last few years the increase of malaria in Worli has been attributed to the presence of large numbers of labourers imported from up-country employed on the Development works in that area, and a similar increase in Fort North has been ascribed to the work on the Ballard Estate. As regards the recent reclamation operations at Back Bay, which are still in progress, a special medical officer, Captain B. S. Chalam, was put in charge of anti-malarial operations, and he has succeeded in keeping the disease in that area under complete control.

Preventive Measures Undertaken

Prior to the time of Bentley's investigation the true causes of malaria in Bombay were not understood, and it was generally supposed that flooding and lack of drainage were the chief factors in the incidence of

the disease.* It was therefore natural that such efforts as were made with the object of preventing or controlling malaria were of little effect; indeed Bentley stated in his report that previous to the year 1908 there was reason to believe that the disease increased rather than diminished during the period when supposed anti-malarial work was in progress.

As has been already mentioned, a Special Malaria Department of the Municipality was created in 1912, abolished in 1918, restored in 1923, and continues in existence up to the present day. The principal measures undertaken by the Department may be briefly summarised as follows:—

1. *Treatment of Breeding-places—*

(*a*) A number of wells have either been filled in or covered over with concrete, with or without the provision of a trap-door.

(*b*) Cisterns have in many cases been rendered mosquito-proof.

(*c*) Tanks in various parts of the City have been filled in or treated with larvacides.

(*d*) Pools have been treated with pesterine and other larvacides, including paris green.

(*e*) Large numbers of odd receptacles have been removed.

(*f*) Larvacidal fish have been used in the case of wells, fountains and tanks. This measure was practised in Bombay as early as 1902. It was stated in the Executive Health Officer's report for 1912 that a number of wells were stocked with *Anabas scandens*, the climbing perch, locally known as Khajura. In the report for 1913 it was stated that this species not having proved very successful another species, *Haplochilus lineatus* (Piku), was tried. This was the fish experimented with by Aitken in some of the Bombay fountains, and called by him "scooties"; apparently he found them effective in reducing larvæ, until they attracted the attention of certain small boys who found great sport in catching them. In 1915 it was noted that both the above-mentioned species were under trial, but that the results were disappointing. "It is our experience that for some time fish are effective, but later on larvæ continue to appear." Up till the year 1917 varying numbers of wells are cited as being "under fish trial," but this measure appears to have been abandoned about that time. In the Health Officer's Note of 1925 already referred to, it was proposed to revert to the measure of stocking wells with fish, "abandoned because of the difficulty of keeping the fish alive." At the present time both Khajura and Piku are being used, and in the report for 1927 it was stated that 144 wells were "under fish trial."

2. *Free Distribution of Quinine and Cinchona Febrifuge.*

3. *Propaganda—*

Placards, leaflets and hand-bills have been distributed, lantern lectures given from time to time, and weekly reports of places where Anopheline breeding has been found published in the newspapers.

* This idea is still by no means uncommon in Bombay, even amongst medical men.

4. *Legal Action—*

Every year the reports contain the record of hundreds of prosecutions instituted and warning notices sent to offenders.

Besides the Municipality, other public bodies in Bombay have carried out anti-malarial work. As the result of Bentley's recommendations the City Improvement Trust deputed one of their subordinate officers to pay special attention to the question of mosquito breeding-places on their estates; the Port Trust appointed two European Inspectors with a small staff for anti-malarial work; the G. I. P. and B. B. & C. I. Railways appointed a European Inspector and a small staff; and the P. & O. Company deputed one of their subordinate staff to inspect the area under their control.

At the present time the Port Trust employ one Malaria Inspector, two Sub-Inspectors, 5 muccadams and about 40 coolies; the B. B. & C. I. Railway one Inspector and 4 coolies; the G. I. P. Railway one Overseer and 12 coolies; and the Development Department one Inspector, one muccadam and 12 coolies, solely for anti-malarial work.

It is abundantly clear from a study of the Executive Health Officer's annual reports that the work of the Malaria Department has been carried on in the face of great difficulties. Repeated references are found year after year to large numbers of wells and cisterns with trap-doors or covers left open or in a non-mosquito proof condition. Every report contains records of hundreds of wells found to contain mosquito larvæ. References to various notorious sources of breeding appear with depressing regularity, notably to the Bhuleshwar Tank, to the cellars on the Ballard Estate and to breeding-places in the large railway yards and public gardens, and in connection with building construction.

The principal obstacles to the work of malaria prevention appear to have been the absence of unity of control of anti-malarial operations, apathy and lack of co-operation on the part of owners of property, the inadequacy of legal powers, and in particular the fact that such legal powers as have existed have not been applicable to Government Departments, railways and other public bodies.

CHAPTER III

THE ANOPHELINE MOSQUITOES OF BOMBAY AND THEIR BREEDING-PLACES

The Species Recorded

The following species of Anopheline mosquitoes were encountered in the island of Bombay by Bentley :—

A. subpictus Grassi (" *rossii* " Giles).
A. stephensi Liston.
A. jamesii Theobald.
A. barbirostris Van der Wulp.
A. fuliginosus Giles.
A. listonii Liston.
A. culicifacies Giles.

With the exception of *A. subpictus* and *A. stephensi*, the above-mentioned species were present in extremely scanty numbers. All those encountered except *A. subpictus* were most frequently found breeding in wells. The larvæ of *A. stephensi* were found only in the south of the island, principally in wells situated within houses, whilst those of the other species were almost entirely confined to the wells in the northern half of the island.

At one time *A. listonii* was fairly common in the vicinity of the reservoirs at Malabar Hill and Mazagon, where it was found breeding in the streamlets formed by leakages from the water works ; but even in Bentley's time it had apparently disappeared from these localities.

During the present inquiry examples of all the above species have been met with, and in addition *A. vagus* Donitz and *A. pallidus* Theobald. *A. vagus* had previously been recorded in Bombay by Chalam, but the presence of *A. pallidus* had not been noted before. As was Bentley's experience, all the species except *A. subpictus* and *A. stephensi* were met with in exceedingly scanty numbers. The results of catches of adult Anophelines made during the course of the inquiry are given below :—

Species	Numbers caught	Percentage of each species
A. subpictus	8,443	90·2
A. stephensi	855	9·1
A. vagus	37	0·4
A. culicifacies	18	0·2
A. pallidus	3	....
A. fuliginosus	2	....
A. listonii	1	....
A. jamesii	1	....

No adult specimens of *A. barbirostris* have been caught, but the larvæ of this species were found on one occasion in an open well.

In addition to the species already mentioned, James and Liston recorded that a single specimen of *A. tessellatus* Theobald (" *punctulata* ") was caught in a house at Parel. This species has not been met with in the course of the present inquiry, but was recorded by Marjoribanks as occurring in certain localities in the east of Salsette Island.*

Of the ten species of Anopheline mosquitoes which have been recorded in Bombay, only *A. subpictus* and *A. stephensi* exist in sufficiently large numbers to exert any influence in the transmission of malaria, the remainder being so rare as to be of interest only to the entomologist.

A. subpictus, which is by far the most common Anopheline in the island, has never yet been found infected in nature in India except on one doubtful occasion, although many thousands of specimens have been dissected in various parts of the country. It occurs all over the island, the larvæ being found in collections of water of every description, and it is present in large numbers in localities where malaria is practically non-existent. This species may safely be ruled out as a possible carrier of malaria in Bombay.

A. stephensi was conclusively proved by Bentley to be the sole malaria carrier of any importance in the island, a finding which has been fully borne out by the results of the present inquiry. This mosquito is the one malaria-carrying Anopheline in India which can adapt itself to the conditions obtaining in cities. It is generally regarded as one of the most important malaria carriers in this country, and it is also held to be the chief agent in the transmission of the disease in Lower Mesopotamia. It is notorious as being pre-eminently the well-breeding Anopheline of India, the larvæ having been found in the wells in Delhi, Calcutta, Madras and numerous other localities throughout the country.

Liston in Bombay recorded the exceedingly high infection rate of 25 per cent. in this species during the course of the great malaria epidemic of 1908, but he did not state the numbers dissected. Bentley dissected over 1,200 specimens in the course of his investigation, and found and infection rate of 7·4 per cent., the proportion found infected during the month of August 1910 being as high as 18·4 per cent. During the same investigation he dissected 772 specimens of *A. subpictus*, none of which showed any evidence of malarial infection.

In the course of the present inquiry 671 specimens of *A. stephensi* have been dissected, of which 28 (4·2 per cent.) were found to harbour malarial parasites. 17 were found to have oöcysts in the stomach wall, and 12 to have sporozoites in the salivary glands. The first infected mosquito was caught on the 10th July.

From the above account it will readily be understood that a detailed study of the breeding-places of *A. stephensi* in Bombay is essential, for it is upon the eradication of these breeding-places that the success of any antimalarial scheme in the City depends.

* In the first edition of James and Liston's Monograph it was stated that *A. theobaldi* and *A. jeyporiensis* had been found in Bombay. These statements were omitted in the second edition, and were probably incorrect.

The Principal Breeding-places of *A. stephensi* in Bombay

Before discussing these, it is very necessary that certain basic facts regarding the bionomics of this mosquito shall be thoroughly grasped. These facts must constantly be borne in mind during the consideration of the problem of malaria control in Bombay.

(*i*) *A. stephensi* requires fresh water, preferably constantly renewed, to breed in. This preference for fresh clean water is by no means peculiar to this species, for it is shared by most of the chief malaria-carrying mosquitoes throughout the world, the majority of which are primarily stream-breeders. *A. stephensi* will not breed in foul or stagnant water, thus differing conspicuously in its habits from the harmless *Anopheles subpictus*, and from the Culicine mosquitoes whose attacks cause such bitter complaints from many of the residents of Bombay. Hence the foul-smelling open sewers of Bombay, however unpleasant and harmful they may be in other respects, have no bearing upon the malaria problem. Similarly, stagnant swamps and natural ponds are of practically no importance in this respect. For instance, Dharavi village, which is surrounded by ponds and swamps, is almost entirely free from malaria.

It must be emphasised that the "mosquito nuisance" and the question of adequate schemes of drainage in Bombay are problems entirely separate from that of malaria control.

(*ii*) *A. stephensi* will breed with equal facility in dark places and in those exposed to the direct rays of the sun, and the larvæ will flourish in any depth of water from a fraction of an inch to 20 feet, or indeed probably to any depth. The breeding-place may be situated below the level of the ground, or on the roof of a building 80 to 100 feet in height. Frequent disturbance of the water, such as is produced for instance by drawing water from a well by means of a bucket, will not prevent breeding.

(*iii*) In order to reach its breeding-place, *A. stephensi* requires only the narrowest of openings through which to pass. **By the term "mosquito-proof" is meant a condition where there is no aperture greater in size than the mesh of an ordinary mosquito-net.**

In the case of Bombay, hundreds, or rather thousands, of breeding-places exist which fulfill the above conditions, all be it noted provided by man. The most important of these are:—

1. *Permanent Breeding-places*, such as wells, cisterns, fountains, garden tanks and tubs, water used in building construction, cellars into which sub-soil water percolates, leakages from reservoirs, etc.

2. *Temporary Breeding-places*, formed only during the rainy season, such as improperly graded roof-gutters and terraces, empty tins and other receptacles, ill-drained yards and vacant building plots, hollows in machinery and scrap-iron, unfinished and abandoned buildings, and cellars which become flooded during the monsoon.

These will now be considered in detail.

1. *Permanent Breeding-places—*

Under this heading are classed those breeding-places which are in existence at all times of the year, in contradistinction to those which are produced only during the monsoon.

(*a*) WELLS—

It was proved by Bentley that the presence of wells was the principal cause of the persistence of endemic malaria in the southern portion of the City. More than half of those in A Ward were found to contain the larvæ of *A. stephensi*, these being particularly numerous in the wells situated within houses. In the Executive Health Officer's reports from 1921 to 1926 the presence of mosquito larvæ in wells was recorded on 2,629 occasions, but it was not stated whether or not these were Anophelines. In the report for 1927, however, it is stated that Anopheline larvæ were found in wells in 1,086 instances.

The striking correlation between the presence of house wells and the incidence of malaria was emphasised in a most interesting report by Drs. B. S. Shroff, Kapadia and Daji on an investigation into the causes of malaria amongst the Parsees, carried out in 1911. They found that the spleen rate amongst children living in houses with wells was no less than 59·34 per cent., a figure nearly 20 per cent. higher than that found in the case of children living in houses without wells.

Bentley recommended that the wells should be either filled in or completely covered over, with or without the provision of a pump. There was, however, a considerable amount of opposition to this proposal on the part of certain house-owners, who stated that it was against their religious principles to cover the wells hermetically. He therefore recommended that where these objections were put forward the wells should be covered, but that a well-fitting trap-door should be allowed, with the proviso that this should be kept closed when the well was not being used, and maintained in a mosquito-proof condition. This proved to be a most unfortunate concession, for experience has since shown that the continued existence of wells which are not hermetically covered in Bombay is disastrous.

The trap-doors are constantly left open, the wooden frames of the doors speedily warp and shrink, whilst rents in the wire gauze are of common occurrence. *A. stephensi* will enter a well or cistern through the narrowest possible opening, and it is a rare experience indeed to find a trap-door in a mosquito-proof condition. The annual reports of the Executive Health Officer contain repeated references year after year to large numbers of wells found with trap-doors left open or in bad repair, and with mosquito larvæ present in the water.

Thus the provision of trap-doors is useless as a preventive measure. Indeed, in some respects it is worse than useless, for it engenders a false sense of security and renders proper inspection impossible. As Bentley pointed out, the larvæ of *A. stephensi* are extremely sensitive to danger, and when alarmed will dive and remain below the surface of the water for 20 minutes or more. It will therefore readily be understood that unless they are present in large numbers the result of letting down a well-net through a small aperture will be negative.

There is no doubt that the number of cases in which the presence of larvæ in wells has been recorded, large though it is, does not represent by any means the number in which they have actually been breeding.

In 1911 there were in Bombay 4,380 wells, out of which 3,280 were situated in the southern half of the island. The total number now in existence is 3,026, of which 597 are hermetically covered and may therefore be ruled out as possible breeding-places. The remaining 2,429 wells are either completely open or are fitted with a trap-door. Thus wells alone provide 2,429 potential breeding-places in Bombay. Of these 1,539 are fitted with a trap-door, and are situated almost entirely in the southern half of the island. Most of the 898 open wells are located in the northern half of the island.

The presence of insufficiently protected wells is the principal cause of the persistence of endemic malaria in the southern part of the City. So long as they are allowed to remain in their present condition this portion of Bombay, which includes the Docks and most of the more important business premises of the City, will be exposed to the danger of periodical outbreaks of malaria.

(*b*) CISTERNS—

In 1911 the total number of cisterns in the City was 4,887. There are at the present day no less than 25,846, and the number is increasing every year with the expansion of the water-carriage system of conservancy.

Cisterns have in the past been a prolific source of Anopheline breeding in Bombay. In times of scarcity of water the man-hole covers were constantly left open by servants and others who obtained water by dipping it out of the cisterns. The recent provision of an adequate piped water supply has greatly diminished this pernicious practice, but the inspection of many hundreds of cisterns in different parts of the City has convinced me that they are still a serious source of danger. The presence of unprotected cisterns, particularly the great "sprinkler tanks" is the chief cause of the very serious amount of malaria existing in the mill areas; and as a factor in the incidence of the disease in Bombay at the present time they are of even greater importance than are the wells.

The principal defects which have been noted in cisterns in the course of the present inquiry are as follows:—

(*i*) *Covers of cisterns*—

There are in Bombay 213 cisterns without a covering of any kind, and 188 others which have corrugated iron covers. The cisterns in both these categories are for the most part very large, and include the "sprinkler tanks" which are required by the Fire Insurance Companies to be installed in each mill, and the large overhead cisterns found in railway areas and dockyards.

Corrugated iron covers are most unsatisfactory, as even if they are mosquito-proof when first put on (a rare event), they become inefficient in a very short time, and any attempt made to repair them usually only makes matters worse.

In one instance I have seen a very large cistern in a mill covered with tarred canvas. This was torn in several places, and a man-hole had been improvised by the simple process of cutting out three sides of a square and raising the flap so formed, which was gaping open at the time of my visit.

Another defective type of cover was found in the staff quarters of the B. I. S. N. Company's Dockyard. In this instance two very large cisterns just under the roof had been covered with wire gauze, in which were many rents. Over the gauze covering wooden boards were laid. In addition to the holes in the gauze there were gaps along the edge of the wooden frame work amply sufficient for mosquitoes to enter.

In many of the large overhead cisterns in connection with mills and railway yards there is a gauge for telling the level of the water, which consists of a float connected to a pulley by a chain or wire passing through an aperture in the cover of the cistern. It is of course impossible for a cistern fitted with this type of gauge to be mosquito-proof.

(*ii*) *Man-hole and valve-box lids*—

Lids are not infrequently either left open or improperly closed, either by workmen repairing the roof who have dipped out water for their work, or by persons washing themselves or their clothes. The latter is a surprisingly common practice, even when there is a convenient supply of water from a tap at hand, and the cistern is comparatively difficult of access.

Man-hole and valve-box lids are frequently ill-fitting. It is particularly difficult to make the rectangular valve-box lids fit properly. As regards man-hole lids, a standard pattern of cap-cover approved by the Municipality has now been provided in the case of some 23,000 cisterns in Bombay.

Only a small proportion of lids of cisterns are provided with locks, and those present are usually of a type which may be obtained in the bazaar for the price of one anna. These rapidly become unserviceable, and can be wrenched off with the greatest ease.

(*iii*) *Holes in cisterns*—

These are sometimes due to corrosion, and in other cases to the fact that a pipe has been removed for some reason, and the hole left uncovered.

(*iv*) *Absence of check-nut on inlet pipe*—

This is a not infrequent defect, which results in a hole being left at the side of the pipe. An attempt is sometimes made to stop this up by means of cement or putty, but this device is never effective for any length of time.

(*v*) *Cover of warning-pipe*—

In a large number of instances the wire gauze covering has been found missing or defective. A type of brass cap with perforations is now being fitted to a number of cisterns, and appears to be very

efficient. A possible drawback to this is that anything made of brass is of value in the bazaar, and is therefore liable to be stolen.

(*vi*) *Inlet-pipe entering through man-hole*—

This was found on one occasion in a mill, in the case of two very large cisterns which had originally been installed in a ship. Needless to say, it is impossible for a cistern with a pipe entering through the man-hole to be mosquito-proof.

(*vii*) *Inaccessibility of cisterns*—

In quite a considerable percentage of cases it is positively dangerous to attempt to inspect cisterns, as for instance when one has to cross a wall about 15 inches wide with a sheer drop of 80 feet on either side, or to scramble over a steeply-sloping roof. In other cases the trap-door in the roof is too small. Sometimes there is no ladder at hand, and a great amount of time is wasted before one is discovered. When finally produced this is often rickety and unsafe, with possibly several rungs missing.

Cisterns are also sometimes found situated immediately beneath the roof, making it impossible to examine them properly. The amount of valuable time wasted owing to the inaccessibility of cisterns is incalculable.

(*c*) Large Ponds and Tanks—

The majority of these are found in connection with mills. The substitution of the electric drive for steam-power in the majority of the Bombay mills has increased the danger from this source, though they are of relatively less importance from the point of view of malaria than are wells and cisterns. One of the reasons for this is the presence of large numbers of aquatic insects which prey on mosquito larvæ, and which are absent in the case of wells and cisterns.

In addition to the mill-ponds there are a number of large tanks in connection with temples.

(*d*) Fountains, Garden Tanks and Tubs—

These are a fruitful source of Anopheline breeding, and constitute a very definite danger to the health of the City. The majority are situated in D Ward, which contains many houses with large gardens, belonging to the most wealthy section of the population. Almost every garden in this locality contains several masonry tanks and iron or wooden tubs, many of the latter being sunk in the ground. The presence of these dangerous breeding-places, the adequate inspection of which would entail the employment of a very large staff, is the chief source of malaria in this part of Bombay.

There are also several fountains and about 60 masonry tanks in the Victoria Gardens, which have been notorious sources of Anopheline breeding for many years.

(*e*) Water used in Building Construction—

I have been particularly impressed by the enormous amount of mosquito breeding which goes on in the water used during the construction of reinforced concrete buildings, in order to keep the

cement-concrete wet whilst it is setting. I have seen this water teeming with the larvæ and pupæ of *A. stephensi* on the roof of a building* 80 feet high, exposed to the full heat of the sun. Larvæ are also to be found even when the work is being carried out below the level of the ground, *e.g.*, during the construction of a concrete drain.

The tubs used for soaking bricks during building operations are also sources of Anopheline breeding.

(*f*) Leakages from Reservoirs, Water-pipes, etc.—

These collections of water form ideal breeding-places for *A. stephensi*, as the water is slow-flowing and is constantly renewed. In former times the reservoirs at Malabar Hill and Bhandarwada Hill were notorious for the amount of malaria existing in their vicinity. Even now the Old Bodyguard Lines, situated immediately below the former reservoir, are malarious, and larvæ of *A. stephensi* are to be found in seepage water in the gardens on the side of the hill.

Seepage water percolating through into the holes excavated in stone quarries is also a most favourable source of breeding for *A. stephensi*.

Bursts in water-pipes are not infrequent, and larvæ of *A. stephensi* are to be found in collections of water arising from this source.

(*g*) Road-watering Hydrants—

The original pattern of hydrant installed in various parts of the City consists of a small chamber in the roadway or pathway protected by an iron cover. This chamber very frequently contains water in which mosquitoes may breed, as has been pointed out on many occasions in the Executive Health Officer's annual reports. The cover has a small hole in it, for the purpose of inserting a "key" when it is required to raise it, which provides a convenient means of access for mosquitoes. The hydrants are also frequently tampered with by the public, who often leave the covers open. Since 1919 a new stand-pipe pattern of hydrant has been introduced, but a large number of the old pattern still remain.

(*h*) Cellars—

Certain cellars on the Ballard Estate contain water throughout the year, caused by percolation of the subsoil water. It is very difficult to treat these effectively with larvacides, or even to examine them thoroughly. They form dangerous permanent breeding-places, and as they are situated in close proximity to the Alexandra Dock, they are a source of danger to the ships berthed there.

It is astonishing that this state of affairs, which was brought to notice by the Executive Health Officer several years ago, and has been alluded to in his annual reports on many occasions, should be allowed to persist in a modern City.

(*i*) Pools on the Foreshore—

These breeding-places are discussed in detail in Chapter VII, under the heading "Mosquito breeding in salt and brackish water."

* The building in question was being constructed in the compound of a large hospital, and was situated within a few yards of a ward full of patients. I was told that the work had been in progress for two years.

2. *Temporary Breeding-places*—

Under this heading are classed all breeding-places which are produced during the rainy season only.

(*a*) CELLARS—

Allusion has already been made to cellars which always contain a certain amount of water percolating from the subsoil water. There are others which are dry during the greater part of the year, but which become flooded when the level of the subsoil water rises during the monsoon. They form very important breeding-places, because, unlike most collections of water of a temporary nature, they are not scoured out by further falls of rain. There are a number of these on the Ballard Estate.

(*b*) YARDS CONTAINING MACHINERY; SCRAP-IRON, ETC.—

The most important of these are the large railway yards and mill compounds. These yards, sometimes many acres in extent, often contain an enormous quantity of disused machinery, tubs, barrels, rails, etc., among which myriads of collections of water are formed during the monsoon. They constitute one of the principal causes of the "mosquito nuisance" in Bombay, as they provide ideal breeding-places for Culicine mosquitoes. The larvæ of *A. stephensi* are also frequently found in such situations, particularly when permanent breeding-places are present in the vicinity. In the case of mills and railway yards these are usually provided in plenty by the presence of open or imperfectly protected cisterns.

(*c*) UNFINISHED AND ABANDONED BUILDINGS—

Several of these exist on the Ballard Estate. In the monsoon rain-water collects on every floor, and on the ground underneath the buildings, which has in many cases sunk below the level of the surrounding land.

(*d*) ROOF-GUTTERS AND TERRACES—

These are frequently not properly graded, thus allowing water to collect during the rains. When rain falls at frequent intervals, these collections of water get scoured out, but during breaks in the monsoon they become a source of danger. Whilst inspecting buildings in the more modern quarters of the City, one cannot help wishing that the contractors had spent a little less money on providing marble floors, etc., and a little more on properly levelling and grading the terraces and gutters.

(*e*) OLD TINS, EARTHENWARE VESSELS, ETC.—

These provide breeding-places for *A. stephensi* during the rains, although the larvæ of *Stegomyia* and other Culicine mosquitoes are more frequently found in them.

Recommendations for dealing with the various breeding-places mentioned in this Chapter will be found in Chapter VI.

CHAPTER IV

THE PRESENT DISTRIBUTION AND INTENSITY OF MALARIA IN BOMBAY

Methods of Investigation Employed

The degree in which malaria is present in any community is best measured by the examination of children living in the locality for enlargement of the spleen, and for the presence of malarial parasites in the peripheral blood. In the course of the present inquiry two methods of procedure were employed :—

(*a*) Various parts of the City were visited at random, and wherever possible 100 children of between the ages of two and ten years were examined. All new-comers were excluded, and as far as possible only local-born children were selected. In this way 4,123 children were examined for splenic enlargement. Blood specimens (thick films) were taken from 3,447 of these and examined for the presence of malarial parasites, ·05 c.mm. of blood being searched in each case before a film was returned as negative. This part of the investigation was carried out between April 1st and May 5th. The results are recorded in Appendix E, Table I.

(*b*) A spleen census was taken of Municipal School children throughout the island, those of over ten years of age being excluded. In all, 286 schools were visited and 27,647 children were examined. Pupils are supposed to attend these schools from the age of six years upwards, but it certainly appeared that a number of those examined were below this age. When a child was found to have an enlarged spleen, his address was taken down and inquiry made as to his movements during the previous two years. The ideal course would have been to record these particulars in the case of every child examined; but this was found to be impracticable, on account of the amount of time taken up in so doing. The results of the census are recorded in Appendix E, Table II. In this Table, information is given in the "Remarks" column in the case of any child found to have an enlarged spleen who had arrived in the locality in question within the previous two years. It is very necessary to subject the figures obtained from a census of this kind to careful analysis, for in the case of an area where endemic malaria is very slight the arrival of a few families from a highly malarious locality may otherwise give an entirely erroneous impression.

The observations made during the present inquiry have the great value that every child was examined and every spleen measurement made by me personally, so that the results obtained throughout the series are strictly comparable one with another. This part of the investigation was carried out between June 19th and August 17th; it could not be commenced earlier owing to the schools being closed for the vacation.

Christophers' method of measuring the position of the apex of the enlarged spleen and Sinton's method of enumerating the malarial parasites found in the blood were employed. The details of these observations are not however included in this report, as they are of scientific interest only, and do not affect the conclusions and recommendations set out in the following pages.

Discussion of Results

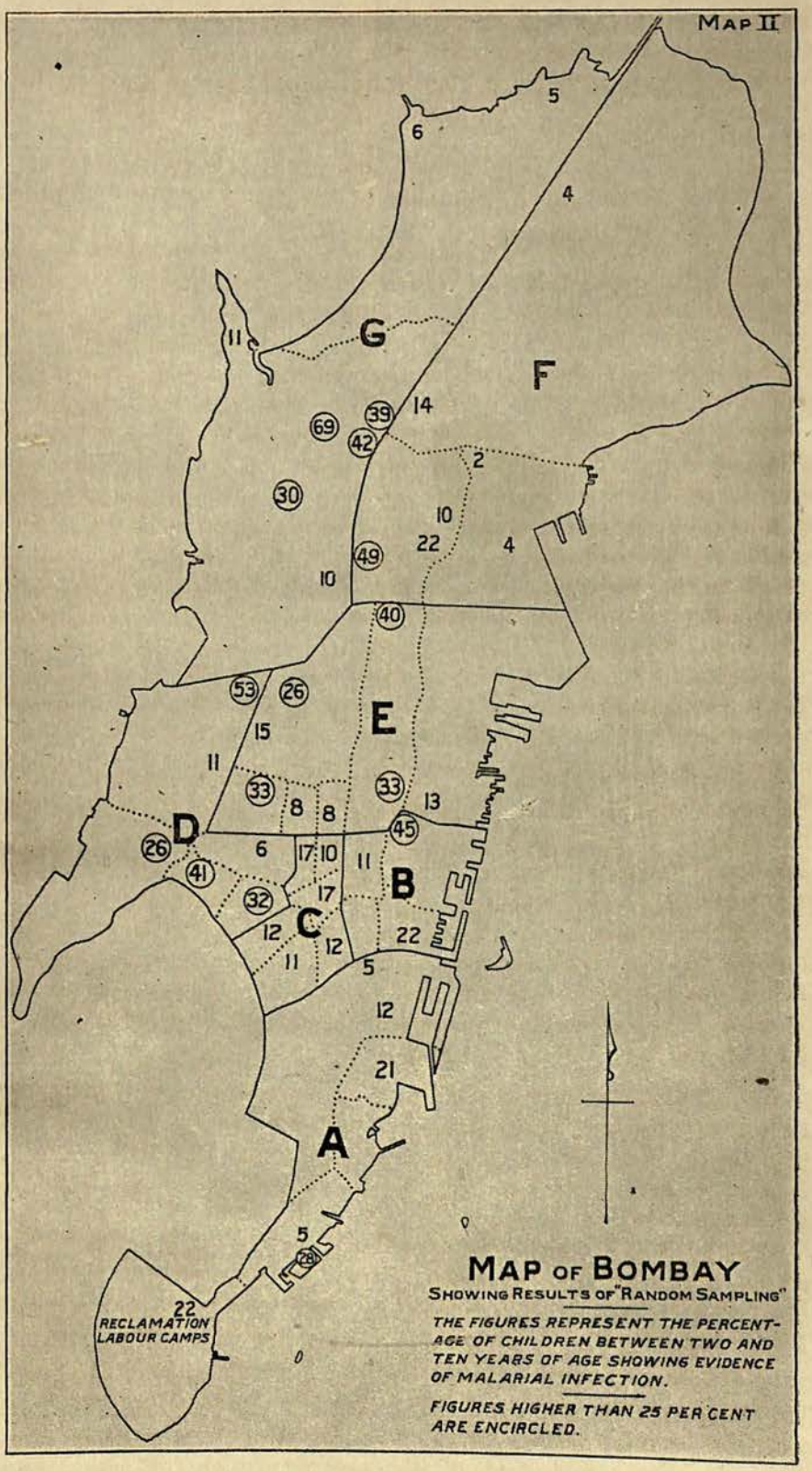
In examining the results obtained by the above methods of investigation, it is necessary to remember that the observations were made for the most part during the least malarious period of the year, and in a year following two exceptionally mild malaria seasons.

The first series of observations showed that the intensity of malaria varies very much in different parts of Bombay, some localities being almost entirely free from the disease, whilst in others more than half of the children examined showed evidence of infection. Moreover, so remarkably localised is the disease that there may be a serious amount of malaria among the occupants of a particular set of tenements, whilst a few streets away there is very little evidence of the disease. It must be emphasised therefore that the figures given in Map II, which represent the percentage of children showing evidence of malarial infection in various localities in the island, cannot be taken to represent the intensity of malaria existing throughout any given Section of the City, but only the degree present in the particular locality in that Section in which the examination was carried out.

The second series of observations, namely the spleen census of Municipal School children, confirmed the general distribution of the disease already ascertained, whilst supplementing the information obtained in certain important respects. It is probable that the figures obtained are on the whole rather too low, because in the first place the observations were made during the monsoon, when less robust children are liable to be kept at home in the event of heavy rain, and in the second place owing to a strike which was in progress during the whole of the inquiry, a considerable number of the mill-hands, who live in the most malarious parts of Bombay, had left the City with their families.

A diagrammatic representation of the present distribution of malaria in Bombay, based on the results of the spleen census of the school children is given in Map III. In discussing the results of these observations it is necessary to point out the danger of pooling the figures obtained throughout any one Section of the island. Some of the Sections are very large, and it may happen that there is very little malaria over the greater part of a Section, whilst in one quarter there may be a serious focus of the disease. The latter fact may be entirely masked by the practice of massing together all the figures for one Section.

At the time of Bentley's investigation (1910-1911), the most intense malaria was found to exist in the vicinity of the Alexandra Dock, which was then under construction, *i.e.*, in Esplanade, Fort North and Mandvi Sections. Further west there was another larger area, including the


MAP II
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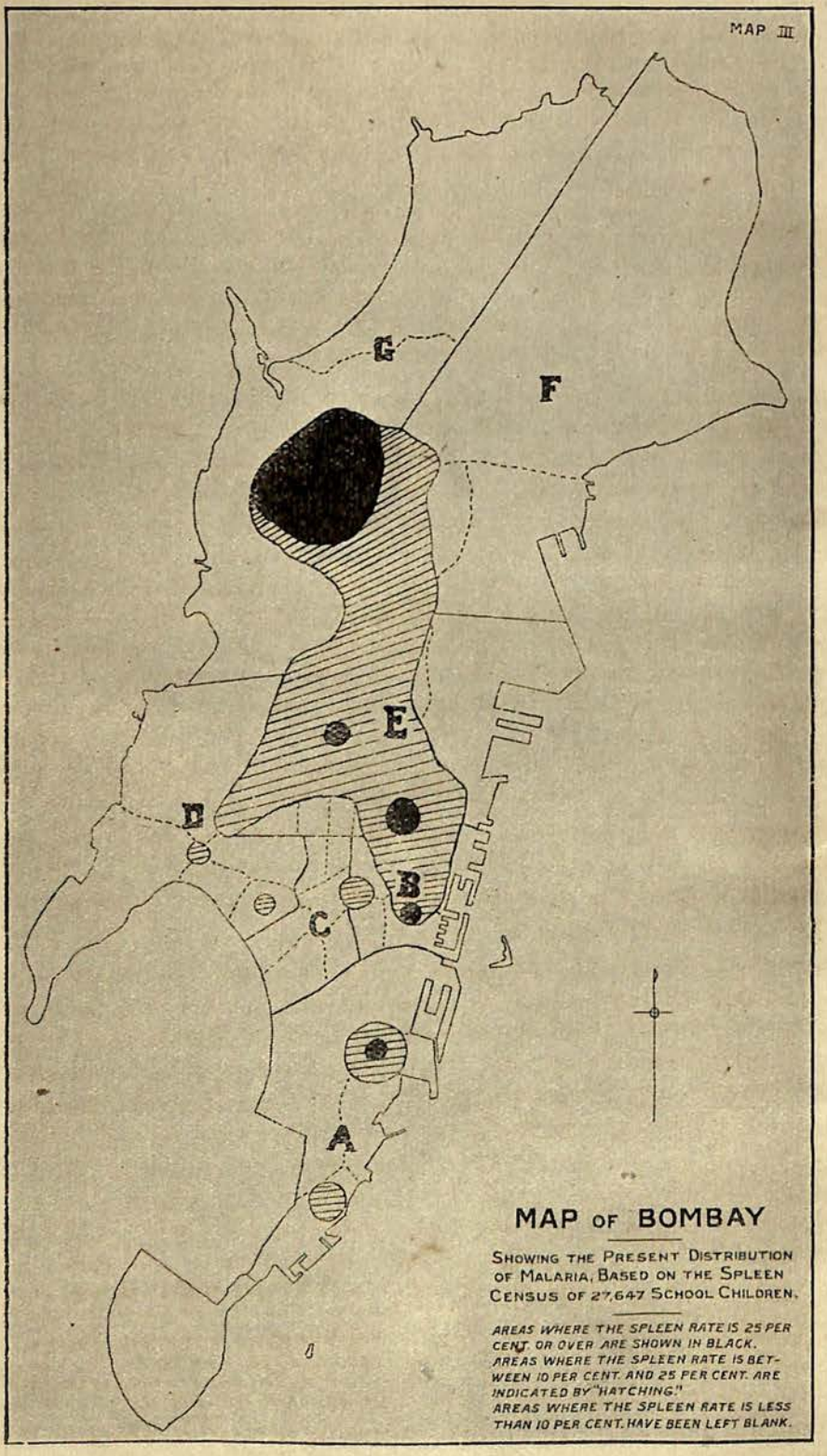
RECLAMATION LABOUR CAMPS
MAP OF BOMBAY
SHOWING RESULTS OF "RANDOM SAMPLING"
THE FIGURES REPRESENT THE PERCENTAGE OF CHILDREN BETWEEN TWO AND TEN YEARS OF AGE SHOWING EVIDENCE OF MALARIAL INFECTION.
FIGURES HIGHER THAN 25 PER CENT ARE ENCIRCLED.



MAP OF BOMBAY

SHOWING THE PRESENT DISTRIBUTION OF MALARIA, BASED ON THE SPLEEN CENSUS OF 27,647 SCHOOL CHILDREN.

AREAS WHERE THE SPLEEN RATE IS 25 PER CENT. OR OVER ARE SHOWN IN BLACK.
AREAS WHERE THE SPLEEN RATE IS BETWEEN 10 PER CENT. AND 25 PER CENT. ARE INDICATED BY "HATCHING."
AREAS WHERE THE SPLEEN RATE IS LESS THAN 10 PER CENT. HAVE BEEN LEFT BLANK.

central and western portions of Fort North, Fort South, Dhobi Talao, Chuckla and Market Sections, in which the disease was severe. There were minor foci of malaria in the vicinity of Malabar Hill and Bhandarwada reservoirs, but the main distribution of the disease was practically limited to A, B and part of C Wards. Malaria was almost non-existent in the northern half of the island, *i.e.*, in Mahim, Sion, Worli, Parel and Sewri Sections.

The present investigation has shown that the disease has now become very much more widely diffused. It is still present in certain quarters of the southern portion of the City to a serious extent, but the most intense malaria at the present time exists in the vicinity of the mills, more especially in Worli and Parel Sections.

In the extreme north and north-east of the island, *i.e.*, in Mahim, Sion and the north-eastern part of Sewri Sections, the amount of malaria existing remains extremely slight, though there is a perceptible rise in the spleen rate in Naigaum, Dadar and Parel Bhoiwada, in the south of Sion. It is noteworthy that the most northern parts of the island, which are the least malarious, are low-lying and subject to extensive flooding during the monsoon. In the northernmost portion of Worli Section malaria is also slight, but as soon as the edge of the mill area is reached the incidence of the disease rises abruptly and extends over the greater part of Worli and Parel. There is also a considerable amount of malaria over the whole of Byculla Section, extending in the south-west into Tardeo, and in the south-east into Tarwadi and 1st Nagpada, with a zone of highest intensity lying to the south-west of Byculla Station. The southern portions of Tarwadi and Mazagon, the whole of Dongri, the northern part of Umarkhadi and the eastern part of Mandvi are also highly malarious, the principal focus in this quarter being in the vicinity of Valpakhadi, at the point where Tarwadi, Mazagon, Umarkhadi and Dongri Sections join one another.

Turning now to the south-western part of the island, the spleen census appears to indicate that there is no considerable amount of malaria over the greater part of Walkeshwar, and but little in Mahalakshmi except in the extreme eastern portion. There is a small zone of higher incidence in Chowpati in the immediate vicinity of Victoria Mill, but except for minor foci in Girgaum and at the junction between Chuckla and Bhuleshwar the percentage of enlarged spleens in the remainder of D Ward and almost the whole of C Ward is not very high. It is however evident that there exists an appreciably greater amount of malaria in Chowpati, Girgaum, Fanaswadi and Dhobi Talao than in the more central parts of the City, where the incidence of the disease is very slight indeed.

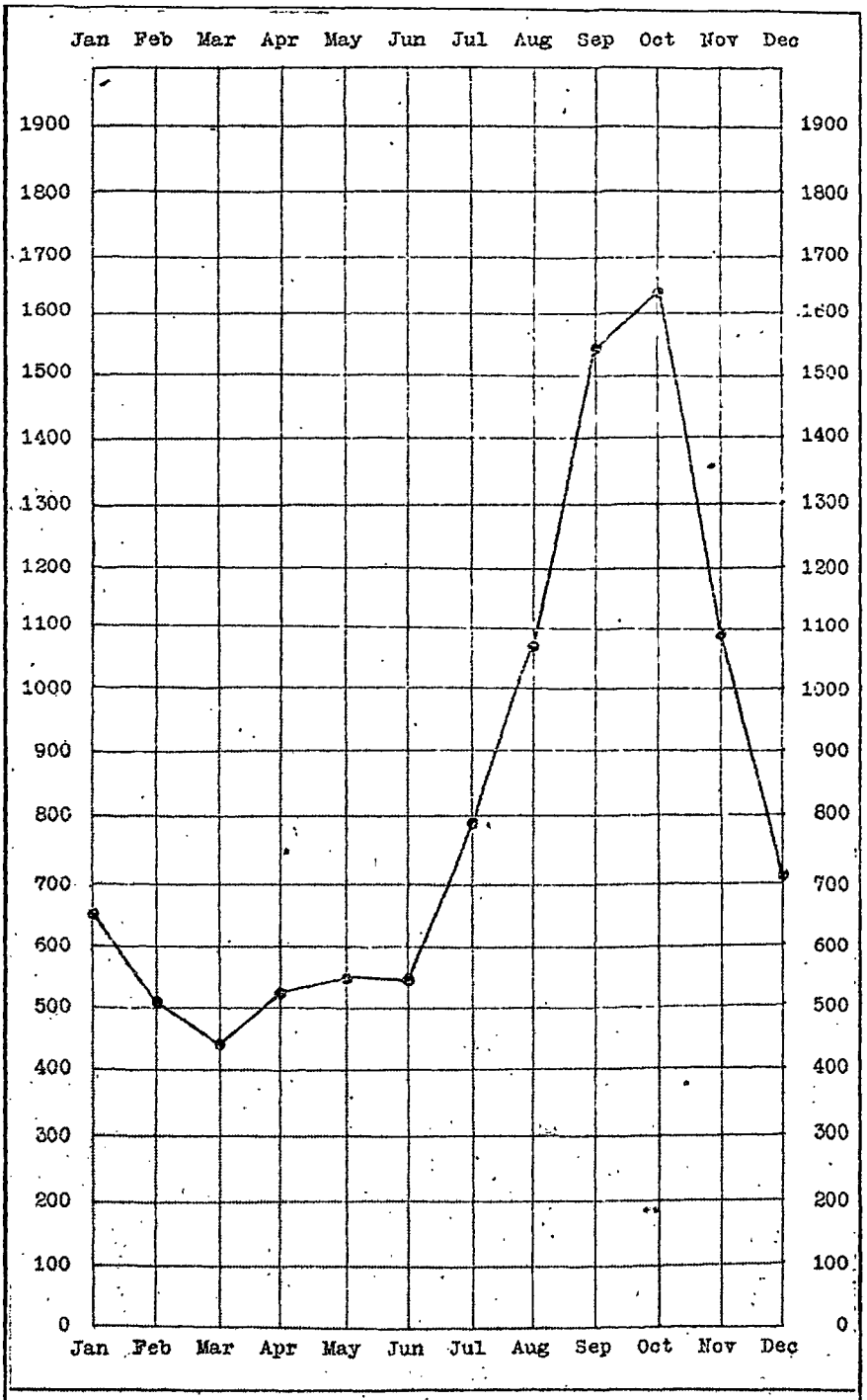
I am inclined to think that there is considerably more malaria in the southern parts of D and C Wards than the results of the spleen census appear to indicate. My reason for taking this view is that the Municipal School children in this area come from a distinctly higher social class than do the majority of those in the northern or central parts of the island, and it is probable that if they get an attack of malaria they receive

medical treatment, and that therefore the percentage of palpable spleens among them is considerably lowered. Support is lent to this view by the fact that in the first series of observations, out of 100 children examined in Girgaum 28 were found to harbour malarial parasites in their blood, although only 8 showed enlargement of the spleen. Throughout C and D Wards the parasite rate almost invariably exceeded the spleen rate, whereas in the other parts of the island the reverse was usually the case. It is interesting to note that Bentley in his investigation found in C Ward a spleen rate of only 5·9 per cent., although the parasite rate was 27·7 per cent. I think the explanation must be that these children during their actual attacks of fever receive treatment which is sufficient to control symptoms and moderate the enlargement of the spleen without resulting in a parasitic cure.

In A Ward there is manifestly a serious centre of infection in the Fort area, whilst in the southern portion of the Ward there is a small focus in the immediate vicinity of the Colaba Land Mill.

In every case where malaria has been found to be present to any serious extent, permanent breeding-places of *A. stephensi* have been found in the immediate vicinity. Thus in Valpakhadi there were large masonry cisterns on the roofs of the Municipal tenement buildings in which the man-holes were completely unprotected, there being no trace remaining of the wire gauze which formerly covered them. The quarries at Nowroji Hill close by contained seepage water in which were numerous larvæ of *A. stephensi*. At Clerk Road (Tardeo Flats) the huts in which the children were living were situated on the bank of a storm-water drain; a cross-drain entering this from under the B. B. & C. I. Railway line was partially blocked with old baskets, etc., and was breeding *A. stephensi*, whilst a large cistern over the latrines was without a man-hole cover. Again, above the Old Bodyguard Lines below Malabar Hill larvæ of *A. stephensi* were found in seepage water produced by leakages from the reservoir. In the Fort area and in the southern portions of C and D Wards the prevalence of the disease is to be attributed to the presence of numerous insufficiently protected house-wells, cisterns, fountains and garden tanks.

In most of the remaining cases the source was found to be breeding-places in connection with the mills. **The correlation between the intensity of malaria and the proximity of mills was most striking,** especially in certain cases where a single isolated mill happened to be present, *e.g.*, the Victoria Mill in Chowpati and the Colaba Land Mill in Colaba. In the former case a number of children living in a blind alley abutting on the wall of the mill-compound were examined. Almost all those residing in the houses close to the mill had enlarged spleens, whilst at the other end of the alley cases of splenomegaly were comparatively rare. The vast majority of the mills in Bombay are situated in the highly malarious area shown in Map III in Worli and Parel Sections. The breeding places existing in connection with the mills and elsewhere are discussed in detail in the following chapters.



Graph illustrating the Seasonal Incidence of Malaria in Bombay, compiled from the records of the Port Trust Dispensary, 1923-1927.

To face page 31

It is noteworthy that in the most congested central part of the City where there are no mills or gardens and but few wells, and where the old insanitary system of basket privies has not yet been replaced by the water-carriage system, malaria is comparatively slight.

The Seasonal Distribution of Malaria in Bombay

From a study of the records of cases of malaria treated at various institutions in Bombay for a large number of years it is evident that the seasonal incidence of the disease is very regular. The least malarious month in the year is usually March. The monthly incidence of the disease is very slightly higher in April, and remains practically constant throughout April, May and June. The " malaria season " begins in the latter half of July, and from then the incidence steadily rises to its highest point, which is usually reached in October, September and October being the two most malarious months. In November the number of cases occurring falls rapidly, and continues to decrease until the minimum figure is reached in March. The seasonal incidence of the disease is well shown in the accompanying Graph, which has been constructed from the figures obtained from the Port Trust Dispensary for the past five years.

The seasonal distribution of malaria in Bombay is what one would expect from the results of catches and dissections of adult mosquitoes carried out during the present inquiry. Until the latter part of June adult Anophelines of all species were extremely rare. The numbers of *A. stephensi* began to increase at the beginning of July, and the first infected specimen was captured on July 10th. The monsoon commenced on June 10th.

Further details with regard to Anopheline catches and dissections are given in Chapter III.

CHAPTER V

CONCLUSIONS

The Present Position as regards Malaria in Bombay

In the preceding pages it has been shown that in spite of the expenditure of a considerable amount of money and labour on anti-malarial measures, yet the disease remains a serious source of illness and loss of revenue to Bombay, and that it is considered to be one of the principal causes of the high infantile mortality in the City. The Mills, the Railways and in certain instances the Municipality itself are directly responsible for a large amount of the malaria existing amongst their employees.

With the completion of the Alexandra Dock and the preventive measures which have been taken against breeding-places in the immediate vicinity, the incidence of malaria has diminished in that locality. On the other hand, there still exists a serious amount of malaria in the southern part of the City, and as we have seen the disease has spread to an alarming extent in a northerly direction, involving the greater part of the area where most of the mills are situated.

It is difficult to say with certainty what has been the chief cause of the spread of malaria towards the northern part of the island. Probably several factors have participated, amongst which the following may be mentioned :—

(*i*) Increased facilities of communication between the south and north of the island.

(*ii*) The northward shift of the population. The numbers residing in Worli Section for example have increased from 69,488 in 1906 to an estimated figure of 1,37,607 in 1927.

(*iii*) The enormous increase in the number of cisterns in F and G Wards, from 92 in 1911 to 5,257 in 1928.

(*iv*) The presence of a large encampment of labourers at Worli during the construction of various development works in that locality. These suffered very severely from malaria.

(*v*) The vast number of breeding-places which must have been created during the construction of reinforced concrete buildings.

The Cause of Malaria in Bombay

There is no natural malaria in Bombay, the chief reason being the absence of natural streams. *Anopheles stephensi* is the only species of mosquito which plays any appreciable part in the transmission of the disease in the island, and its breeding-places are exclusively man-made. As was explained in an earlier chapter, this mosquito is the one malaria-carrying Anopheline in India which is able to adapt itself to life in a

large city. In the case of other carriers facilities for breeding suitable to their needs are not produced in urban areas. But *A. stephensi* is the great well and cistern-breeder of India, and unless these breeding-places and others of a similar nature are rendered permanently mosquito-proof it will continue to flourish even in the heart of the City.

An exact parallel is provided in Palestine by the case of *Anopheles bifurcatus*, which is the only urban malaria-carrier in that country, and which also breeds freely in wells and cisterns. The campaign directed against these breeding-places in Jerusalem, formerly a hot-bed of the disease, has been attended with conspicuous success.*

Although many changes have taken place in Bombay since 1911, the root cause of the persistence of malaria in the island remains the same as it was at the time of Bentley's investigation, *i.e.*, the existence of thousands of permanent breeding-places, artificially produced by man, which are admirably adapted to the needs of the particular malaria-carrying mosquito of Bombay.

Bentley's recommendations were aimed at the complete eradication of autochthonous malaria from the island, and before proceeding further it is necessary to discuss the following questions, which at once arise for investigation :—

(*i*) To what extent have Bentley's recommendations been put into practice ?

(*ii*) Were his proposals sufficiently far-reaching to accomplish the result at which they were aimed ?

Have Bentley's Proposals received a Fair Trial ?

(*a*) *Anti-malarial Staff*—

The appointment of a *whole-time* Malaria Officer was regarded by Bentley as the most important part of his whole scheme. A special officer was appointed in 1912, but the appointment was abolished in 1918. In 1923 the post was restored, but at the present time the officer in charge of anti-malarial operations has other duties to perform in addition to those connected with malarial prevention.

As regards the remaining staff, only a small proportion of the minimum recommended was at first sanctioned, and even after the reconstitution of the Malaria Department in 1923 the numbers employed fell far short of Bentley's recommendations. Recently, however, the staff has been increased, and the budget strength is now approximately the same as that proposed by Bentley in his Scheme II, which aimed at the abolition of malaria-carrying mosquitoes in Wards A, B, C, D and E only.

(*b*) *Legal Powers*—

The existing section of the Municipal Act regarding the prevention and control of breeding-places was amended in 1913, but the full powers asked for by Bentley have never been granted.

* See *List of References to Literature*, No. 5.

(*c*) *Mosquito Breeding-places*—

One of the chief points in Bentley's scheme was that all large tanks, fountains, garden tanks and tubs, and wells not filled in or hermetically covered should be licensed, and the license was to be renewable annually. By this means he hoped that a large number of persons would prefer to have the wells filled in or hermetically covered, rather than pay an annual tax, and that a number of fountains and tanks would be converted into flower-beds. Any tank, fountain or tub found breeding was to have the license withdrawn, and be filled in or removed. This proposal was not carried out.

Most of his other recommendations with regard to breeding-places have been adopted, but not with the complete thoroughness which he stipulated. For instance, a very considerable proportion of the cisterns now in existence are not properly mosquito-proof.

Were Bentley's Proposals sufficiently Far-reaching ?

The results of the present inquiry have confirmed Bentley's conclusions in every particular, but in the light of the experience gained during the 17 years which have elapsed since his report was written, there appear to be certain defects in his scheme. As has been pointed out earlier in this report, the concession allowing trap-doors to be provided in the case of wells has proved to be most unfortunate, and has certainly contributed to the persistence of malaria in the southern portion of the City. Another drawback to the scheme was the failure to insist on unity of control of all anti-malarial operations in the Island of Bombay. This question also is dealt with elsewhere.

The conclusion is thus reached that in the first place Bentley's proposals have never fully been carried out, and in the second place, although his observations and deductions were entirely sound, yet in the light of our present knowledge his recommendations did not in certain respects go far enough.

Reasons for the Comparative Failure of Preventive Measures

These may briefly be summarised as follows :—

(*i*) The lack of unity of control of anti-malarial operations throughout the Island of Bombay.

There are large areas in the island which are under the control of bodies other than the Municipality, these being the Military Authorities, the Bombay City Improvement Trust, the Development Directorate, the Port Trust, and the B. B. & C. I. and G. I. P. Railways. Most of these bodies are carrying out anti-malarial work independently, but the successful accomplishment of the work is very largely dependent upon the ability and knowledge of the individual in charge. The subject of malarial control constitutes a very special branch of preventive medicine, and special training is necessary. In some cases the present system has worked admirably, but in others it has left much to be desired; and there is no guarantee that an efficient malaria officer may not be removed elsewhere and replaced by one who possesses but scanty knowledge of the subject.

Apart from these considerations the system is uneconomical, and cases have occurred where recommendations of the Malaria Officer of the Municipality have been ignored on the ground that some other body whose land adjoined the area in question had failed to carry out necessary measures of control.

This state of affairs leads to endless correspondence, and to delay in carrying out anti-malarial work of vital importance to the community at large. Meanwhile, the breeding of malaria-carrying Anophelines proceeds unchecked; and it need scarcely be pointed out that the mosquito does not respect the fence or wall which marks the boundary of the area controlled by this or that authority.

(*ii*) The inadequacy of the existing legislative powers, which has gravely hampered the Malaria Department in its task.

(*iii*) The fact that such legal powers which exist have not been applicable to the Railways and Government Departments.

(*iv*) Lack of co-operation in carrying out preventive measures on the part of the officers controlling these bodies, and on the part of the Municipality itself. This has been and still is one of the greatest factors in the comparative failure of preventive measures.

(*v*) The adoption of half-measures of control, which has proved to be both wasteful and ineffective. As has been pointed out above, in no single instance have Bentley's recommendations been carried out in their entirety.

(*vi*) Insufficient staff. This deficiency has now been remedied, so far as numbers are concerned.

(*vii*) The lack of a sufficient piped water-supply, prohibiting the complete abolition of certain dangerous breeding-places. There is now an ample supply from this source, and there need be no further delay in carrying out the necessary measures on this account.

Is it possible to eradicate Endemic Malaria completely from Bombay ?

As has been already stated, there is no natural malaria in Bombay, and Bentley showed that in 1911 the disease was practically non-existent in the northern half of the island. Even now malaria is almost entirely absent in the extreme north and north-east, and there are parts of the City in which the incidence of the disease is very slight.

There is no doubt that the complete eradication of malaria from Bombay at the present time is a very much more difficult problem than it would have been some years ago, when the disease was confined to the southern half of the island. Nevertheless, seeing that there is for all practical purposes only one malaria-carrying mosquito in Bombay, and that all its permanent breeding-places are artificial and capable of being either completely abolished or rendered innocuous, I believe that it is practicable to stamp out endemic malaria from the island; and that this can be accomplished at a cost considerably less than the amount at present lost annually by interference with labour and by expenditure on account of medical aid to those suffering from the disease.

Should Measures be directed against All Mosquitoes?

This question has frequently been debated, and it has been urged that measures should be undertaken against all mosquitoes on the following grounds :—

(*i*) That all mosquitoes are a nuisance.

(*ii*) That certain species of Culicine mosquitoes are capable of transmitting filariasis, dengue and yellow fever.

Personally, I am of opinion that the campaign should be limited at present to an intensive attack on the malaria-carrying Anopheline for the following reasons :—

(*i*) For an *effective* campaign against all mosquitoes, a very large increase of staff would be necessary. Culicine mosquitoes will breed in any and every collection of water, whether foul or fresh. The larvæ are to be found in open sewers, drains and collections of water in hoof-prints, tins, fragments of coconut shells, roof-gutters, broken bottles on walls, etc. Bentley estimated that five lakhs of rupees would be the annual cost of a successful scheme, but at the present day the cost would be very much greater. If the Malaria Department as at present constituted professes to be engaged in a war against all mosquitoes, it will inevitably fall into disrepute.

(*ii*) An even greater objection is the fact that the adoption of measures against all mosquitoes tends to fog the issue, and to distract attention from the main object. If the breeding-places of all mosquitoes are attacked, there is a very grave chance that a portion of those which are most dangerous from the point of view of malarial prevention may be overlooked. The elimination of as many as possible of the breeding-places of *A. stephensi* in Bombay, and the maintenance of those which remain in a mosquito-proof condition is a task sufficient to absorb the entire time and energies of the Malaria Department; and nothing should be allowed to interfere with the attainment of this object.

Essential Requirements for a Successful Anti-malarial Scheme in Bombay

(*i*) The effective organisation of the Malaria Staff.

(*ii*) Unity of control of anti-malarial measures over the whole Island of Bombay.

(*iii*) The adoption of a systematic campaign with the object of abolishing all permanent breeding-places of the malaria-carrying mosquito of Bombay.

(*iv*) Preventive measures to be of a permanent nature wherever possible.

(*v*) The provision of effective legislation to enforce the necessary measures.

(*vi*) This legislation to apply to the Railways, all Government Departments, and in fact to all public and private bodies in the Island of Bombay.

(*vii*) Active co-operation in the carrying out of preventive measures on the part of the Officers controlling the Railways, Government Departments and other public bodies, and on the part of the Municipality itself.

CHAPTER VI

PREVENTIVE MEASURES NOW RECOMMENDED

General Considerations

The essential requirements for the success of antimalarial measures in Bombay have been tabulated in the preceding chapter. There are, however, certain other considerations which must be taken into account in formulating any such scheme.

It must be borne in mind that the principles laid down in any report of this nature are usually quickly forgotten. Notable examples of this are provided by the history of two of the most outstanding malaria reports which have ever been written, namely, Bentley's report on Bombay and Christopher's report on the Andamans.

In both these instances some of the specific measures advocated were carried out, but in the course of a few years the principles upon which they were based were forgotten. In Bombay we have seen that the Special Malaria Department, the creation of which formed the keystone of Bentley's whole scheme, was abolished seven years after the submission of his report ; and even now it is a common experience to hear the statement that the flooding of low-lying grounds and the presence of open sewers are the chief factors in the causation of malaria in Bombay. In the case of the Andamans the principles laid down by Christophers were similarly forgotten, and 14 years after his report was submitted villages and convict barracks were in existence in close proximity to the salt swamps which form the breeding-places of the dangerous Anopheline mosquito which is the carrier of malaria in those islands.

Nothing is more certain than that a similar fate will befall the present report ; and it is for this reason that in the following pages every effort has been made to avoid generalisations, and to describe the measures recommended for malarial prevention with what may at first sight appear to be unnecessary detail. It is hoped that the adoption of permanent measures in every possible case, and the rigorous enforcement of the necessary regulations in cases where this is impracticable will ensure that the one great object of the campaign, *i.e.*, the eradication of every potential permanent breeding-place of *Anopheles stephensi*, may be attained. The details of the scheme now proposed are given below.

Organization of the Malaria Staff

1. *The Special Malaria Officer—*

(*a*) As was emphasised by both Bentley and Christophers, and as will be evident from a perusal of the present report, the task of the officer in charge of antimalarial operations in Bombay is a very arduous one. The major portion of his work lies *in the field*, and it

is essential that the antimalarial campaign shall be carried out under his immediate personal supervision.

This officer should have no other duties whatsoever except those connected with the prevention of malaria. Further, as the study of malaria control is a very special subject, I consider that any officer in future appointed to this post should be a trained malariologist. I would also suggest that the Director, Malaria Survey of India, be asked to arrange if possible that prior to taking up his duties this officer should attend one of the malaria courses held from time to time under his direction.

(*b*) Unity of control of antimalarial operations over the whole of Bombay is of vital importance. The drawbacks of the present system have been discussed at some length in the preceding chapter. I wish to make it quite clear that I do not desire to criticise in any way the work of those who are at present carrying out antimalarial measures in any part of Bombay; but the system is wrong in principle, and is certain to break down on occasions, with consequent detriment to the health of the City in general. I therefore most strongly urge that **all antimalarial operations in the Island of Bombay be carried out under the direct supervision and control of the Special Malaria Officer of the Municipality.**

I am aware that this suggestion has been put forward before, and that it has been rejected owing to various objections which have been put forward. As a substitute a Malaria Advisory Committee has been appointed, which includes representatives of the various public bodies in the island. This Committee* is a most valuable one, and its continued support will strengthen the hands of the Malaria Officer, but I regard unity of control on the part of this officer as being essential to the efficient working of any antimalarial scheme in Bombay. The war against malaria in the City will not be completely successful until all the antimalarial forces in the island are united under one central authority.

2. *The Subordinate Staff.*—

As regards numbers, the present budgeted strength will probably be sufficient, *provided that the recommendations put forward below are adopted.* Under the existing conditions the numbers are entirely inadequate to carry out the duties which they are expected to perform. It is possible that the numbers will have to be increased from time to time to some extent in conformity with the expansion of the City and the opening up of new residential areas.

As regards quality, in certain cases this leaves much to be desired. All antimalarial work implies the conduct of an active field campaign, and the personnel must be both conscientious and energetic. The work of inspection is by no means an easy or pleasant one, and the personal factor is of great importance. There is a tendency on the part of certain Inspectors to confine themselves to office work and to leave the field

* Suggestions for certain alterations in the composition of this Committee will be found in Chapter X.

work entirely to the Sub-Inspectors. This lack of personal supervision inevitably leads to the Sub-Inspector leaving the work to his coolies. It is scarcely necessary to point out that no amount of office work can compensate for a lack of efficiency in the field.

I consider that the present pay of the Sub-Inspectors is insufficient. Their work is very important, and with their present scale of pay they are constantly looking about for some more lucrative post, with the result that there are numerous changes of staff, which is most undesirable. **I recommend that their pay shall be on a sliding scale, rising to a maximum of Rs. 100 per month.** This will tend to attract a better type of man, and to obviate the present continual changes of personnel.

3. *The Work of the Malaria Department.*—

I do not propose to attempt to lay down the duties of the malaria staff in detail, as naturally these must be arranged by the Malaria Officer. There are, however, certain points in connection with the work which call for comment.

At the present time a very large part of the time of the staff is taken up in examining wells, cisterns, etc., for Anopheline breeding. I have emphasised earlier in this report the extreme difficulty of demonstrating the presence of the larvae of *A. stephensi* in wells with trap-doors and in cisterns, unless they are very numerous. One can never be sure, even after spending 20 minutes or more in examining either of these types of breeding-place that larvae are not present. It is a common experience to discover quite a number of larvae after having made about 20 negative dips with a net; and to examine all the wells and cisterns in the City thoroughly once a week would require a staff ten times as numerous as that employed at present.

Under the scheme which I now propose all this labour, which I regard as entirely unnecessary, will be cut out completely. We *know* that every well and cistern which is not mosquito-proof is a dangerous potential breeding-place for the malaria-carrying mosquito of Bombay. Why, therefore, bother to dip with well-nets, hand-nets, etc. (a procedure often perfunctorily carried out) and waste so much valuable time and labour in proving what is already known to be a fact?

Under the scheme now put forward the chief work of the inspecting staff during the dry season will consist not so much in examining collections of water for larvae, as in seeing that every potential breeding-place of *A. stephensi* is maintained in a mosquito-proof condition. If my proposals are adopted as they stand, *every* well will be hermetically covered or filled in and *every* cistern rendered mosquito-proof and provided with a standard man-hole lid which will be locked and the key in the possession of the malaria staff (or of some responsible official in the case of mills, railways, etc.). All that will be necessary with regard to these most important sources of mosquito breeding will be a monthly inspection, conducted on a specified day of the month in each case, not to examine them for the presence of larvae, but simply to see whether they are still completely mosquito-proof. Needless to say, the inspection must be

thorough ; one cannot, for instance, properly inspect a roof cistern from the terrace of the next house. **Furthermore, it must here be emphasised that this rigid inspection must never be relaxed, no matter how low the incidence of malaria may fall in future years.**

In order to become fully acquainted with the work of the inspecting staff, I have on many occasions accompanied Sub-Inspectors on their rounds in various parts of the City, and have been much impressed by the difficulties of their task. It is a frequent experience after having climbed four or five flights of stairs to find the door of the top flat in a building locked and the tenant absent, the only means of access to a cistern on the roof being through the flat in question. Or, the occupant of the flat may object to the Inspector coming through it. Or, having arrived at the top storey it may be found that there is no ladder to reach the trap-door in the roof. Or, that the said trap-door is weighted down by about a hundred tiles. Or, the roof having been reached, that the passage to the cistern is so hazardous as to require the nerve of an acrobat or cinematograph actor to attempt it. Apart from all this, the monotony of going from house to house and climbing four or five flights of stairs in each case must be experienced to be understood.

There is no doubt that in some cases at least the Sub-inspectors have found themselves unable to compete with their task, and have returned to their offices and filled up their record books with wholly imaginary entries. Under the circumstances I do not think that they can be held entirely to blame for this.

The measures described below will reduce the work of the inspecting staff to a very great extent, and I consider that if they are adopted the present staff will be well able to cope with the work of inspection efficiently, without any considerable increase of numbers. I would recommend that owing to the exacting nature of their task, no work whatever should be required of the staff on Sundays. At the same time the rule that the discovery of any false entry in the record books will entail instant dismissal should continue to be rigidly enforced.

There are however other difficulties to be faced by the Malaria Department under the present system. If a well or cistern is found to contain larvae, a letter is written to the occupier or owner of the property requiring him to render it mosquito-proof. A lengthy correspondence frequently ensues, which may or may not culminate in an action in the Courts, as the result of which the offender is either cautioned or "punished" by the infliction of an insignificant fine. A considerable part of the time of the malaria staff is taken up in serving notices and summonses.

It might perhaps be supposed that in the case of public bodies, such as the Railways or Government Departments, it would be easy to get defects remedied. This is far from being the case ; indeed, it is in dealing with such bodies that the greatest difficulties of the malaria staff are experienced. In the case of a private individual resort may be had

to legal action, but in the case of the Railways and other public bodies the Municipal Act is not applicable.

Times without number whilst going round the City with members of the malaria staff have I been told that a well or cistern which is in a non-mosquito proof condition is "under action," or has been "under action" for many weeks, months or even years. Meanwhile the breeding of malaria-carrying Anophelines continues unchecked, with consequent detriment to the health of the unfortunate people living in the vicinity. It is small wonder that members of the Department have at times lost heart and interest in their work under such conditions.

It is hoped that under the scheme now proposed these disadvantages, which at present cripple the whole work of the Department, will to a great extent be eliminated.

The Control of Breeding-places

In dealing with this aspect of the problem, permanent measures should be adopted wherever possible. Every breeding-place finally and permanently abolished represents a definite gain to the health of the City. Temporary measures, such as oiling, etc., should never be employed except when (*a*) the cause itself is temporary, or (*b*) the cost of permanent measures is absolutely prohibitive. In this connection it may be pointed out that permanent measures, although perhaps in the first instance more costly than those of a temporary nature, frequently prove to be more economical in the long run, owing to the constantly recurring expenses of the latter, and the large inspecting staff that has to be employed.

The types of breeding-place particularly favoured by *A. stephensi* are now well known; and the practice of not dealing with such breeding-places until larvae have been actually demonstrated in them is entirely wrong. We have seen how difficult it is to find the larvae in a cistern or in a well with a trap-door unless they are present in very large numbers; and it is certain that the elimination of some of the breeding-places will compel the mosquito to seek others which are not protected. Therefore the principle to be adopted is a simultaneous attack on all breeding-places which are of a character which has been proved to be suitable for the breeding of *A. stephensi*, whether larvae are actually found to be present at the time or not. **It is particularly necessary that the powers possessed by the Commissioner under Section 489 of the Municipal Act, to execute work necessary for dealing with breeding-places at the owner's expense in the event of non-compliance with orders, shall be invariably exercised.**

1. *Permanent Breeding-places.*—

(*a*) WELLS—

The danger of open or insufficiently protected wells has already been discussed in Chapter III. Bentley was most emphatic in stressing the direct relationship between the presence of wells and the intensity of malarial incidence in the southern portion of Bombay, a finding which as we have seen

was strikingly confirmed by the results of the investigation into the causes of malaria amongst the Parsees recorded by Drs. B. S. Shroff, Kapadia and Daji. The closure of a number of the wells has resulted in a marked diminution of the disease in this part of the City ; but in the course of the present inquiry it has been shown that a considerable focus of endemic malaria still remains in this quarter. It is quite certain that the disease will not be eradicated from Bombay whilst these sources of breeding, which as we have seen are especially favoured by *A. stephensi*, not only in Bombay but throughout India, are allowed to remain in their present condition.

At the time when Bentley's report was written, one of the objections to the closure of wells was the inadequacy of the piped water-supply. This condition no longer obtains, and the sole objections remaining are those prompted by religious or sentimental feelings. I cannot help feeling that in the past these objections have been given too great an importance. In this connection I would point out that there are in Bombay thousands of persons belonging to the very castes whose members have raised these objections, who are living in apparent contentment in houses with no wells in the vicinity.

The only solution of this problem is to fill in the wells, or to cover them completely with concrete. The latter course appears preferable, because it has been objected that if the wells are filled in there might be a water famine should the piped supply fail for any reason. If the wells are merely provided with concrete covers, they could be re-opened in an emergency. If it is considered essential to use the water, a pump may be installed ; but otherwise every well must be hermetically covered. **Trap-doors, which as we have seen are useless as a preventive measure, should not be permitted under any pretext whatsoever.**

I am fully aware that objections will be raised to carrying out this measure, but no reform of any importance can ever be carried through without opposition. The wells are a constant menace to the health of Bombay, and if only the authorities concerned will have the courage to carry through this measure, be the opposition what it may, they will confer a lasting benefit on the City, besides immeasurably lessening the work of the Malaria Department.

The large open wells in the north of the island are *at present* of relatively small importance. But the City will continue to expand, and houses will be built in their vicinity. If allowed to remain unprotected, these wells will sooner or later become infected, as has happened in the case of the mill-ponds and cisterns. Therefore the wisest course is to make a clean sweep of them all, and to issue orders that **every well in the island shall be filled in or covered over with concrete, with if**

desired the provision of a pump, by a certain specified date ; in the event of non-compliance the Municipal Commissioner should cause the work to be carried out, and recover the cost from the owner, if considered necessary.

The cost of covering those wells already fitted with a trap-door will be trifling, only a few rupees per well. The larger wells in the north of the island will probably cost about Rs. 500 each ; and it is a matter for consideration as to whether or not the owners should be compelled to bear the cost.

I understand that in the case of temples there may be insuperable opposition to covering the wells, even if the installation of a pump is allowed. There are in the whole island 135 unprotected or insufficienly protected wells in connection with temples ; and if these are allowed to remain as they are it means that there will still exist 135 potential breeding-places of *A. stephensi*, many of them situated in the heart of the City.

If, however, the closure of these wells is found to be absolutely impossible, then it is best to remove the covers of those which have trap-doors completely, and to stock them with fish. This will entail frequent inspections, and moreover since a well in a Parsee temple may only be inspected by a Parsee, and one in a Hindu temple by a Hindu, it will mean a duplication of staff. Some of the temples have two or more wells, and it should be possible at least to insist that each temple should have not more than one well which is not hermetically covered.

(*b*) CISTERNS—

The importance of cisterns as a factor in the dissemination of malaria in Bombay, and the principal defects in them which have been brought to notice in the course of this inquiry have been discussed in Chapter III. They form the principal source of breeding of *A. stephensi* in the case of the mills, in the neighbourhood of which as we have seen the most serious amount of malaria in the island exists at the present time. If malaria is to be eradicated from Bombay, it is of vital importance for cisterns to be completely eliminated as possible sources of mosquito breeding.

(i) All cisterns must be covered with sheet-iron or reinforced concrete. —

The latter is perhaps preferable in the case of very large cisterns, because it lasts very much longer and because if properly constructed there is no possibility of rain-water collecting on the top ; but owing to its weight it cannot be employed unless the supporting structure of the cistern is sufficiently strong. Great care must be taken to see that the junction between the cast-iron side of the cistern and the concrete cover is made absolutely mosquito-proof. A number of the large sprinkler and hydrant cisterns in

the E. D. Sassoon group of mills have recently been covered in this manner. Slightly different methods have been used in different cases, with the object of finding the most suitable from the point of view of malaria prevention. In the case of the first one erected (Alexandra Mill) the junction between the side of the cistern and the cover was unsatisfactory; but in the remainder this difficulty appears to have been successfully surmounted. It will be necessary to watch this point during the next few years, so that any defect which may arise may be dealt with.

The cost of covering cisterns in this manner has varied from 10 to 12 annas per square foot, depending upon the position of the cistern. It is estimated that the cost of covering all the large cisterns in the E. D. Sassoon group, which comprises 10 mills, will be about Rs. 12,000.

The cost of covering large cisterns with sheet-iron including that of the angle-irons and supports, works out at approximately Rs. 1-2-0 per square foot. A disadvantage of covering very large cisterns by this method is that the covers tend to sag and produce depressions in which water collects during the rains. Larvae of *A. stephensi* have been found in such collections.

Corrugated iron sheets should not be permitted as coverings for any cisterns. The defects of this type of cover have already been noted.

(ii) Water-gauges necessitating an aperture in the roof or side of a cistern must be prohibited.

These are present in the case of a number of the very large overhead cisterns in connection with mills and railways. The only types of gauge permissible are those which do not allow any aperture through which a mosquito can pass.

(iii) Man-hole lids (and valve-box lids if present) to be well-fitting, and of the pattern approved by the Municipality.

The man-hole lid approved is a circular cap-cover, the rim of which fits over another rim fixed in the cover of the cistern. There is one point in which this could be improved, which consists in the shortening of the bar which is fixed across the top of the lid, so that both hinge and hasp are as close to the lid as possible. This will ensure that the lock can only be applied when the lid is accurately closed, and will prevent people prising open the lid and bending the bar. I have actually seen the result of this practice in a number of cases, and the effect is to render it impossible thereafter to close the lid completely. Lids with the hinge and hasp fitted close to the cap-cover are provided in the case of certain cisterns on the roofs of houses at Sassoon Terraces, Mazagaon, and are the best pattern that I have seen.

Square or rectangular iron man-hole lids are most unsatisfactory, and should never be permitted. In the case of large cisterns with reinforced concrete covers, which are only required to be opened once in six months, a square block of concrete is permissible ; but this must be cemented round the edges after being closed on each occasion.

(iv) No inlet-pipe must enter a cistern through the man-hole.

(v) Every inlet-pipe must be provided with a check-nut, or in the case of large cisterns with concrete covers with a double flange secured by bolts through the cover.

(vi) The warning-pipe must be protected by the standard pattern of cap approved by the Municipality.

The protection of warning-pipes by means of wire gauze is unsatisfactory, as the gauze rapidly perishes.

(vii) A strong pattern lock for man-hole lids (and valve-box lids where present) to be provided by the Municipality.

Every hundred (or more, if found convenient) locks to have the same key. Locks to be stamped with the Government mark. In the case of mills, railways, etc., the keys to be kept by some responsible official. The Malaria Officer to be informed as to who has charge of the keys in each case. In the case of domestic cisterns, the keys to be kept by the Malaria Inspector of the Ward in question. **Any owner or occupier of a house tampering with the lock of a cistern should be liable to a penalty.**

It appears that the only legitimate reasons for opening the lid of a cistern are (*a*) to clean it out, and (*b*) to adjust the valve if this gets out of order. In actual practice the lids of domestic cisterns are practically never opened for the first of these reasons, and but rarely for the second. They are much more frequently opened because it is less trouble to dip out a bucketful of water from the cistern than to fill it from a tap which may be situated on a floor below ; or by persons who prefer to rinse their clothes in the cistern. It may be mentioned that in the B. I. S. N. Company's Dockyard the smaller cisterns, which are identical with the ordinary domestic cisterns, have their man-hole and valve-box lids actually rivetted on. This would scarcely have been done if it were necessary to open the lids at frequent intervals.

Under the present scheme the Malaria Sub-inspector will visit each house on a specified day of the month, and if the tenant wishes to clean out the cistern he can arrange to do so on this day. If on the other hand the valve gets out of order, he can at once send to the office of the Malaria Inspector of the Ward. Although this may be less convenient for him than keeping the key in his own possession, he will be able to get it much more quickly than if the key is with the owner of the house, who may live a long distance away.

I have been told that it is a not uncommon occurrence for a cistern to overflow for days without being attended to. This is sometimes because the key cannot be obtained from the owner, but apparently many tenants are so indifferent to the affair that they simply do not bother to take any action. Under the circumstances I do not think that the keeping of the keys by the malaria staff will involve any great hardship, and it will be of inestimable value for the Department to have this important source of breeding under its direct control.

(viii) Proper means of access, to the satisfaction of the Special Malaria Officer of the Municipality to be provided in the case of all cisterns. If a ladder is necessary, this must be of iron, **and must be fixed in position.**

The adoption of this regulation, which although it may appear at first glance to be of a minor character is in reality of great practical importance, will save an enormous amount of time which is now wasted.

(ix) Every cistern to be clearly numbered, to facilitate inspection.

This is another provision of importance. It is quite possible, especially in the case of old houses, to miss out a cistern in the course of inspection. On one occasion in Fort North I came across a cistern the existence of which was not known to the Malaria Sub-inspector. There was no man-hole lid and numerous larvæ of *A. stephensi* were present in the water. This could not have happened if the cisterns had been numbered in series.

(x) Every cistern to be kept in good repair.

(xi) All unserviceable cisterns to be removed.

(xii) Valve-boxes to be prohibited in future.

The provision of an adequate piped water supply has rendered these unnecessary, and many of those more recently installed have no valve-boxes, the ball-cock being accessible through the man-hole. Valve-box lids are a constant source of trouble at present, as it is extremely difficult to make them fit properly. The prohibition of valve-boxes will of course reduce the capacity of the cisterns; but with an ample water-supply this objection should not be allowed to prevent the adoption of this important reform.

(xiii) The Malaria Sub-Inspectors to inspect every cistern in their area on a specified day of each month (*e.g.*, first Monday in the month, etc.), and between certain specified hours. The day and hour in each case to be notified to the owner or occupier of the house.

(xiv) If any cistern is found to be non-mosquito proof, the owner to be given one week's notice to repair the defect,

If no action has been taken within a week, the Municipal Commissioner should cause the work to be carried out immediately, and recover the cost from the owner.

(xv) In future, no new cistern to be installed until it has first been inspected and passed by the Special Malaria Officer of the Municipality.

(*c*) WATER-CLOSET FLUSH-CISTERNS—

Under this heading are classed two types of cisterns, (*i*) the automatic flush cisterns frequently installed in connection with public water-closets and urinals, and (*ii*) the ordinary domestic flush-cisterns with a pull-down chain.

The former are thoroughly bad from the point of view of malaria control. They very frequently get out of order, and the larvæ of *A. stephensi* are often found in them. It is amazing that this type of cistern should have been permitted in a city in which this mosquito was known to exist. At the present time they form a serious source of danger, but I understand that they have already been condemned and will shortly be removed, and therefore they will not be further discussed here.

The domestic flush-cisterns are of various patterns, but they all have either a longitudinal slit about one inch wide by six inches long, or a circular aperture some four inches in diameter in the cover, through which passes the iron bar or chain which works the flush. As long as they are in daily use they are probably of no danger; and even when out of use or out of order (a very frequent occurrence in the poorer localities, where the people do not understand their use) I have never yet found Anopheline larvæ. But they are extremely difficult to examine, on account of the presence of the ball-cock and flushing apparatus, and it must be remembered that when every other source of breeding has been eliminated the mosquitoes will be driven to select any available breeding-place. It cannot be doubted that these flush-cisterns must constitute a possible source of danger at least when they are at first left unused, or when they first become out of order.

It is possible to obtain a type of flush-cistern which has no aperture in the cover. The only one that I have seen in Bombay was made of porcelain, and was therefore very costly, but I see no reason why the same principle should not be applied to a cheaper form. Indeed, it would seem certain that some such pattern must be used in countries where yellow fever exists, for the type at present used in Bombay could not possibly be tolerated in such localities. I would therefore suggest that inquiries be made as to whether an inexpensive pattern of water-closet flush-cistern without an aperture in the cover exists, and that if so this pattern be insisted on in Bombay in future.*

* I understand that flush-cisterns of the pattern indicated are commonly fitted in railway carriage lavatories.

In the meanwhile, I recommend that in their monthly inspections the Malaria Sub-inspectors be instructed to test each flush-cistern, and to pour a tea-spoonful of saponified cresol or other larvacide into the aperture of any found out of order, *before* reporting the fact to the Sanitary Department.

Similarly, when for any reason mills are out of action, each flush-cistern, whether out of order or not, should be treated with a larvacide (*see* Chapter VII).

(*d*) MILL-PONDS—

The majority of the mosquito larvæ found in these ponds are those of *Anopheles subpictus* and of Culicines. The larvæ of *A. stephensi* are however also found in them at times, and therefore although the mill-ponds are less dangerous than are cisterns and wells, it is very necessary to devise a scheme whereby they may be rendered innocuous from the point of view of malaria prevention. The cost of filling in these ponds would be enormous, and therefore it is necessary to employ some form of larvacide. Captain B. S. Chalam and Drs. P. A. Dalal and E. E. Madon have carried out interesting and valuable experiments with a view to finding out the most suitable larvacide for the purpose. In the first set of experiments paris green was used, and in the second a mixture containing three parts of crude oil and two of kerosene, with 0·1 to 0·2 per cent. of castor oil. Both these methods were very successful in destroying Anopheline larvæ, and each has advantages and disadvantages.

Paris green will not destroy the eggs or pupæ of mosquitoes and has no effect on the larvæ of Culicines, but it is extremely efficient in destroying Anopheline larvæ, and has the great advantage of acting equally well whether vegetation or algae are present or not. It does not destroy fish or other natural enemies of mosquito larvæ. It is a very inexpensive method to employ, and being useless for any other purpose it is not likely to be stolen; and since it does not deter mosquitoes from depositing their eggs, it also acts as a trap. It has to be remembered, however, that heavy rain will cause the dust to sink, and therefore should a heavy shower occur immediately after its application, the treatment has to be repeated.

Oil will kill all mosquito larvæ and pupæ, and will deter mosquitoes from depositing their eggs. A disadvantage is that a wind will blow the scum on to one side of the pond. Dalal and Madon found that to ensure complete efficiency it was necessary to employ about one gallon to 100 square feet of surface, which makes it an expensive method. Further, its use offers temptations to unscrupulous employees. Another disadvantage is that some engineers object to any oil being added to the water in the mill-ponds on the ground that it will damage the boilers; though, since the water is withdrawn from the ponds by pipes, the openings of which are usually

about six feet or more below the surface of the water, it is difficult to imagine how this can be so.

Whichever method is to be adopted, it is most necessary that **every mill-pond shall be treated once a week, on a certain specified day of the week throughout the year, whether larvae are found in it at the time or not.** It is only by this procedure that one can be *absolutely certain* that no Anophelines can breed in any mill-pond under any conditions whatsoever.

On the whole, I consider paris green to be the most suitable larvacide, and I recommend that special gangs be formed to carry out the work. There are 117 mill-ponds in the island, and it will thus be necessary to deal with 19 or 20 ponds per day, allowing 6 working days in each week. It should be possible for a Sub-inspector with 3 coolies working under him to treat 5 ponds per day. The ponds should be divided into four groups, each of which should be assigned to one gang. It will be necessary to have a shed in a central position for each group, in order to store the road-dust required, and to keep it dry. Possibly one of the mills in each group could supply a shed for this purpose; otherwise it will be necessary to construct new sheds. Each gang will require a "mixer," and a hand-cart for transporting the dust, which must be collected during the dry months. For use, it is necessary to mix the paris green *thoroughly* with 100 parts of road-dust. This should be done in the shed, and the mixture then taken to each pond in turn. The amount of paris green to be used is 15 grains to each square yard of water surface. Taking the average area of the Bombay mill-ponds to be 40,000 square feet, 1¼ lbs. of paris green will be amply sufficient for one treatment of each tank. The present price of this larvacide in Bombay is about 12 annas per pound. Thus the cost of treating the ponds by this method will be about Re. 1 per pond per week. The total cost of the scheme, calculated on the maximum pay suggested for the Sub-inspectors will be as follows:—

	Rs.
Pay of 4 Sub-inspectors at Rs. 100 per month ..	4,800
Pay of 12 Coolies at Rs. 23 per month ..	3,312
Cost of paris green at Rs. 117 per week ..	6,084
Total cost per annum ..	14,196

It might be found necessary to employ a few extra coolies in the dry season to collect the road-dust, but this would not add very much to the cost of the scheme.

It must be borne in mind that commercial paris green varies in composition, and a chemical analysis should be made of each new lot before employing it. None should be accepted which does not contain at least 50 per cent. of arsenious oxide in chemical combination which is not soluble in water.

I understand that on one occasion in Bombay a mill engineer raised the question of possible damage to boilers from the use of paris green. A similar question was raised in America, where this larvacide has been used extensively in mill-ponds. Apparently it was satisfactorily proved that paris green had no ill-effects on the boilers, even in large quantities, and the owners of one mill offered to put half a pound of the larvacide in a boiler as a demonstration that there was no danger. It seems scarcely possible that there should be any ill-effects from the use of such minute amounts of paris green as are used for the destruction of Anopheline larvæ.

A number of references to the use of this larvacide will be found in the *List of References to Literature* given at the end of this report (Nos. 8, 10, 12, 13, 17, 18, 25).

(*e*) FOUNTAINS, GARDEN TANKS AND TUBS—

The provision of an adequate piped water supply has rendered garden tanks and tubs entirely unnecessary in Bombay. Gardens can be watered perfectly well by means of a hose attached to a stand-pipe, and this method, besides saving time and labour, would probably tend to diminish the present wastage of water from taps left running. Similary, the use of hose-pipe is the most rapid and effective method of washing a motor car.

Fountains provide another very favourable source of breeding for *A. stephensi*, the larvæ of which are frequently found in the basins into which the water falls.

The removal of these three most dangerous sources of breeding will not only lessen the incidence of malaria, but will cause a very great reduction in the numbers of Culicine mosquitoes which abound in that part of the City in which most of them are situated. The following recommendations are put forward :—

(i) All garden tanks to be demolished, or filled in and converted into flower beds if so desired.

(ii) No fountains to be permitted, except those which are so constructed that no water whatever remains when the fountain has ceased playing.

(iii) No garden tubs, barrels or open cisterns in gardens to be permitted.

(*f*) STAND-PIPES—

Should in every case be provided with a cement drain connected with the main drainage system.—

This is a very necessary regulation, especially where the stand-pipes are situated in gardens. In the case of the public gardens below Malabar Hill Reservoir, for instance, the water from the stand-pipes runs down the side of the hill, and forms little pools among the vegetation which are ideally suited to breeding of *A. stephensi*.

(*g*) ROAD-WATERING HYDRANTS—

It has already been explained that the weakest point about the old pattern of hydrant existing in Bombay is the presence of an aperture for inserting the "key" when it is required to raise the cover. It would appear to be a simple matter to replace this by a metal ring which would lie flat when not in use. The covers are studded with metal bosses, which would protect the ring from damage by traffic. The present key-hole should be filled up so that there would be no possibility of mosquitoes entering to deposit their eggs.

I therefore recommend that either the present covers be converted in this manner, or that they be replaced by new covers constructed on the lines suggested above, whichever proves to be the less expensive measure. It would also be of advantage if the covers could be so made that they could not be opened beyond an angle slightly less than a right angle; it would then be impossible for a cover to be left open unless it were propped up.

(*h*) CELLARS—

The owner of any cellar into which the subsoil water percolates should be compelled to fill this in up to such a level that the water no longer percolates into it, even during the rains, by a specified date; failing compliance, the Municipal Commissioner should cause the work to be carried out, and recover the cost from the owner.

Further, as it has been found that newly constructed cellars in Bombay almost invariably allow subsoil water to percolate in, **the construction of cellars should be entirely prohibited in future.**

(*i*) WATER USED IN BUILDING CONSTRUCTION—

In the case of reinforced concrete buildings, the most suitable larvacide is probably saponified cresol. This is inexpensive (about Rs. 3 per gallon), effective, and when added to water gives the latter a milky appearance, so that it can easily be seen by the Inspectors.

Exhaustive tests, carried out by Messrs. J. A. Mitchell and Co., analytical chemists and specialists in cement and concrete, have proved that in a strength of one in one thousand this larvacide not only has no deleterious effect on cement-concrete but even appears to improve its qualities.

A strength of one in 10,000 is probably sufficient to prevent breeding, but it will be more practical to insist that a strength be employed sufficient to render the water distinctly milky (*i.e.*, about one in 2,000). This will cost about two annas for the treatment of 40 gallon barrel, such as is commonly used by builders.

I recommend that all builders and contractors engaged in the construction of reinforced concrete works be required to

add a sufficient quantity of saponified cresol to all water used to keep cement-concrete wet whilst setting to make the water distinctly milky. The cresol must be added to the water *before* it is poured over the concrete, and to all water subsequently added.

A register of the number and location of all reinforced concrete buildings under construction in Bombay should be maintained in the office of the Special Malaria Officer of the Municipality, so that he can at any time make a personal inspection of them.

With regard to water receptacles used for soaking bricks used in building construction, **all such receptacles must be emptied daily after use, and turned upside down.** Alternatively, saponified cresol might be added to the water in the receptacles.

2. *Temporary Breeding-places.*—

Under this heading are classed those breeding-places which are created only during the monsoon, such breeding-places as those formed during building operations having been discussed under the heading "Permanent Breeding-places," because although in a sense they are temporary in nature, they are produced at all times of the year.

Bentley was of opinion that temporary breeding-places were of comparatively slight importance, *provided that permanent breeding-places did not exist in the immediate vicinity*, in which case they at once became a serious source of danger. My own experience has tended to confirm this, for on every occasion on which I have found evidence of any considerable degree of malarial incidence, permanent breeding-places have been found in the immediate vicinity. Conversely, where malaria has been found to be very slight, permanent breeding-places have been absent, although it has frequently been perfectly obvious that hundreds of temporary breeding-places must have been formed during the monsoon.

I do not mean by this that temporary breeding-places are to be neglected, for although our aim is to destroy or render innocuous every permanent breeding-place, it is inevitable that some at least will still remain. I merely wish to emphasise the fact that of the two, permanent breeding-places are relatively the more important, and that the destruction of these should be our primary aim.

There is one class of breeding-place formed during the monsoon that is of a most dangerous nature, and that is the cellars which are flooded by percolation of the sub-soil water when the latter rises during the rains. These have already been discussed in the preceding section along with those into which sub-soil water percolates throughout the year. Other temporary breeding-places are considered below :—

(*a*) YARDS CONTAINING MACHINERY, SCRAP-IRON, ETC.—

These are found in connection with railways, mills and other industrial concerns. Some of them are several acres in extent, and they frequently contain an enormous quantity of discarded machinery, tubs, barrels and other scrap, which form myriads

of breeding-places during the monsoon. In the majority of cases there are permanent breeding-places in the vicinity, and the larvæ of *A. stephensi* are frequently found, whilst since they also form ideal breeding-places for Culicine mosquitoes, these yards are one of the chief sources of the "mosquito nuisance" in Bombay. It is exceedingly difficult to examine the numerous collections of water formed in these places, and quite impossible to treat them all with larvacide.

All such yards should be levelled and adequately drained, and the machinery, etc., so stacked that it provides no hollows in which rain-water may collect. It is quite simple, for instance, to place boiler plates with the convex surface upwards, and to stack rails so that the concave surface is directed sideways instead of upwards. In this connection it may perhaps be remarked that the orderly stacking of machinery and scrap would save the owners of yards a very great amount of space. Articles which cannot be stacked in such a manner that water does not collect in them should be stored under cover during the rains.

In the case of the railways, periodical sales of such machinery and scrap are held, and I would suggest that the Agents of the railways in Bombay be asked to arrange to hold such sales at the commencement of the monsoon.

(*b*) UNFINISHED AND ABANDONED BUILDINGS—

Several of these exist on the Ballard Estate. In the monsoon water collects on every floor, and on the ground underneath them, which has usually sunk below the level of the surrounding land. Each floor should be so levelled that water may no longer collect, and any depression which may exist beneath the building should be filled in.

(*c*) ROOF-GUTTERS AND TERRACES—

In the case of all new buildings, the proper grading of terraces and gutters so that no water can collect should be insisted on.

The only remedy for those already in existence which are improperly graded is to sweep them out periodically during breaks in the rains; but it is obvious that to do this throughout the City would require an enormous staff. It would, however, be of advantage if owners of mills and railway yards, etc., where there are often acres of roofs with hundreds of yards of gutters, could be compelled to have the latter swept down once a week during the monsoon.

(*d*) EMPTY TINS, ETC.—

The presence of discarded tins, earthernware vessels, etc., on roofs or in yards or compounds, found to contain mosquito larvae should constitute an offence punishable by law.

3. *Certain Special Breeding-places.*—

(*a*) BHULESHWAR TANK—

Correspondence has been going on in connection with this notorious breeding-place for more than 15 years. In the Executive Health Officer's report for the year 1925 it was stated that the Municipality had decided to fill it in, but up to the present date no further action has been taken. This plague-spot is situated in a densely populated quarter of the City, and it should be filled in without delay.

(*b*) SLUICE-CABINS AT BHANDARWADA RESERVOIR—

These are two underground chambers constructed for the purpose of turning the water off and on. They are traversed by enormous pipes from which water continually leaks, forming pools on the floor. They form ideal places for the breeding of *A. stephensi*, and in their present condition it is impossible either to examine them thoroughly or to treat them effectively. I understand that it is absolutely necessary to the working of the water supply that these chambers should exist. If this is the case, the floor of each cabin should be filled in up to the level of the bottom of the pipes, covered with cement and properly levelled, graded and drained.

(*c*) MALABAR HILL RESERVOIR—

The doors of this reservoir are not mosquito-proof. They should be replaced by accurately fitting iron or steel doors. The fact that the water is constantly disturbed is no guarantee that *A. stephensi* will not breed in it, for larvæ of this species have repeatedly been found in wells which are in constant use. It is therefore of great importance that reservoirs should be rendered completely mosquito-proof.

(*d*) MALABAR HILL GARDENS—

These are situated on the side of Malabar Hill below the reservoir, and immediately above the Old Bodyguard Lines. This locality was in the past notorious for malaria, and there is evidently a considerable amount of the disease there at the present time, as 9 out of 23 children living in the lines showed evidence of malarial infection.

There are two sources of danger in these gardens, (*i*) seepages from the reservoir, and (*ii*) pools formed where stand-pipes have been left running by the gardeners. As regards the former, cement drains have been made to carry off the water, but the seepages require constant attention. The rock face at which they appear should be kept free of all vegetation, and a close watch kept to see whether water appears at any other points. If it does, it should be conducted by cement channels to the main drains. As for the stand-pipes, recommendations for dealing with these have already been made earlier in this chapter, *i.e.*, a cement channel should be made from beneath each pipe leading down the face of the hill to the drains at the

bottom. These channels should be kept free from overhanging vegetation. I lay particular stress on these points, because larvæ of *A. stephensi* have been found in pools on the side of the hill during the course of this inquiry, and I look upon it as one of the most difficult and dangerous spots to deal with in the whole of Bombay.

(*e*) THE GRASS FARM BETWEEN ELPHINSTONE ROAD AND DADAR—

This covers an area about one mile long and ¼ mile broad, and is situated immediately alongside the track of the B.B.&C.I. Railway. Throughout the year this is irrigated, and in places it is flooded with water to a depth of about six inches. Captain B. S. Chalam investigated this locality in the course of a malaria survey of the railway area undertaken in 1927. He found numerous larvæ of *A. stephensi* in various parts of the grass farm, and conducted experiments with paris green in certain selected areas, which were entirely successful. I understand that even before this date paris green had been employed by the Malaria Department in this area, and I recommend that this measure shall be continued regularly, on the lines laid down for the treatment of mill-ponds. The most effective method of applying the paris green in this locality is probably by means of hand-bellows. I would suggest that the owner of the grass-farm, who I understand makes a very handsome profit from the sale of the grass, be required to meet the cost of the treatment.

There is also an extensive water-logged area by the side of the railway track to the north of the grass farm, in which Chalam noted the presence of larvæ of *A. stephensi*. It would be advisable to include this area along with the grass farm in the scheme for treating the mill-ponds with paris green.

(*f*) THE STORM-WATER DRAIN NORTH OF BELLASIS ROAD—

This is situated to the west of the B. B. & C. I. Railway, and is open from Bellasis Road to Clerk Road, at which point it runs beneath the race-course. The open portion is about ¾ mile in length, and contains water throughout the year. This water is for the most part dirty and foul-smelling, but in places fresh water flows into it from washing-places where the taps are constantly left running. The spleen rate among children living on the banks of this drain at its northern end was 39 per cent., and larvæ of *A. stephensi* were found close by in a cross-drain which enters the main drain at right angles. This was found to be choked with old baskets, etc., and the water in it was clear, fresh water being continually supplied by leakage under the road-bridge, presumably from a defective pipe.

In order to discover whether the main drain was a factor in the high incidence of malaria, 100 children living near the southern end of the drain were examined. Here the rate

was only 13 per cent. It seems probable, therefore, that the cross-drain was the main cause. Presumably both these drains will be covered in when the projected drainage scheme is carried out, but I understand that there is no immediate prospect of this eventuating. In the meantime they should be kept free from débris and vegetation, and the cross-drain should be properly graded. At present there is a rise in the level of this drain beneath the road-bridge.

(*g*) VICTORIA GARDENS—

These gardens form a serious rival to the Bhuleshwar tank as a perennial breeding-place in the reports of the Executive Health Officer for the last 15 years. The most important source of danger is supplied by the small masonry tanks, of which there are about 60, a number of them being overhung by thick bushes. These should come under the general regulations as to garden tanks, *i.e.*, they should be removed entirely. Each stand-pipe should be provided with a cement channel leading to the main drainage system. The question of the fountains has been dealt with earlier in this chapter.

(*h*) OPEN DRAINS IN CONNECTION WITH RAILWAYS—

In the island of Bombay these drains are present in various localities alongside the tracks of both the railways. They are liable to become choked, and in places they are not properly graded. The ideal solution would be that these drains should be covered over. In any case, the railway authorities should be required to have them properly graded, and kept clean and in good repair.

4. *Mosquito Breeding on Barges and Country Boats.*—

Every barge and country boat that enters the Docks contains two or more water-casks, usually situated in the bottom of the craft, and difficult of access. The casks are fixed on their sides, and the only opening in them is a hatch located at the uppermost part, through which water is obtained by dipping.

All these casks swarm with mosquito larvæ, chiefly those of *Culex* and *Stegomyia*. The result is that the ships moored in the Docks and the buildings in the vicinity are invaded by myriads of mosquitoes. This is the cause of numerous complaints on the part of the ships' surgeons and other officers, who aver that Bombay is the worst port for mosquitoes in the East.

The danger of malaria arising from this source is probably not serious; but the average person naturally believes that all mosquitoes can carry malaria, and in any case he cannot be expected to be able to distinguish an Anopheline from a Culicine. Apart from this, these swarms of mosquitoes must seriously interfere with the sleep of the crews of the ships. (The bites of *Culex* and *Stegomyia* mosquitoes are usually much more irritating than are those of *Anopheles*). This state of affairs constitutes a serious nuisance, and is bad for the reputation of the City.

I suggest the following measures, which will presumably involve an amendment to the Indian Ports Act :—

(a) Each fresh-water receptacle on cargo boats entering the Docks to be placed in such a position that it can be emptied into the bilge of the vessel.

(b) Each cask to have a bung-hole opposite to the filling hatch to facilitate rapid emptying, and a well-fitting cover over the filling-hatch.

(c) One of the malaria staff to board each cargo boat before she enters the Docks, empty her fresh-water receptacles and treat her bilges with larvacide. Dock entry to be withheld until this is done.

(d) The Port Trust Authority to provide fresh water for refilling the receptacles.

These craft only remain in the Docks for a few days at a time, and therefore if the above recommendations are adopted the invasion of ships in the Docks by mosquitoes breeding in the water-casks of cargo boats will be enormously diminished.

The Provision of Adequate Legal Powers

No antimalarial scheme in any country has ever been successful without the provision of effective legislation to enforce the necessary measures. The recommendations detailed above can only be carried out if backed by legislative powers which will apply not only to private individuals but also to all public bodies in Bombay, including the Railways and Government Departments.

This question forms the subject of a separate chapter of this report (Chapter VIII).

The Use of Larvacidal Fish

In the chapter dealing with the history of malaria in Bombay (Chapter II) it was noted that fish were used for this purpose as early as the year 1902, and that they are still employed in certain localities in the island.

There are grave disadvantages in the use of fish, most of which, as the reports of the Executive Health Officer testify, have been encountered during the years in which they have been tried in Bombay. The chief are :—

(*a*) Fish are only effective if present in sufficient numbers.

(*b*) They are only completely effective in the absence of all weed and floating débris.

(*c*) Small boys can be relied upon to catch them if they get the opportunity.

(*d*) Over-zealous persons are apt to introduce other and larger species which may prey on the small larvæ-destroying fish.

(*e*) Constant inspection is needed to see that the fish are flourishing and are in sufficient numbers, and that the water is free from weed, algae and floating débris.

(*f*) In order to carry out these inspections, and to keep up a sufficient stock of fish for the various breeding-places, a special staff is necessary for work as "fish-gangs."

I consider the use of larvacidal fish in India only to be justified when for some reason it is found to be absolutely impossible to employ any other measure of malarial control; and in Bombay I think it will be wiser as a general rule to apply the money which would otherwise be expended on this head in more profitable directions.

As has been mentioned above, however, the use of fish is the only course remaining in the case of temple wells and tanks, if the objections to filling in or covering these are found to be insuperable. This measure has also been recommended in the case of the dye-works at Mahim, where it is impossible for technical reasons to apply paris green or oil to the water in the tank.

Free Distribution of Quinine and Cinchona Febrifuge

One cannot help feeling doubtful as to the value of these drugs, unless they are administered systematically and under supervision. They are possibly a useful adjunct to malaria control, but I consider that in the case of Bombay the permanent measures of prevention suggested above, which will *if carried out in their entirety* eradicate or render harmless every permanent breeding place of *A. stephensi* in the island, should hold the first place. Prevention is better than cure, and it is both illogical and uneconomical to spend large sums of money in distributing free quinine, whilst at the same time the root cause of the persistence of malaria in the City is allowed to continue.

CHAPTER VII

SOME SPECIAL PROBLEMS AFFECTING MALARIA IN BOMBAY

The Mills

In view of the very serious amount of malaria existing in their vicinity, special attention has been directed to the mills during the course of this inquiry. In a large part of Worli and Parel Sections malarial conditions approach those encountered in hyper-endemic areas in other parts of India. Not only is there a large percentage of children showing enlargement of the spleen and parasitæmia, but the proportion of greatly enlarged spleens is very marked.

The cisterns constitute the greatest source of danger. Drs. Dalal and Madon, in a report submitted to Messrs. E. D. Sassoon and Co. in May 1928, stated that the larvæ of *A. stephensi* had been found present in every one of the sprinkler cisterns of the E. D. Sassoon group of mills during the preceding year. A detailed inspection of a large number of mills has, however, shown that it is not only the large overhead cisterns which are a source of danger. In the case of every mill there are a large number of smaller cisterns, some inside the mill and others outside it in connection with water-closets and urinals; and in a very large proportion of cases these are not mosquito-proof. The water-closets and urinals are usually provided with the automatic flush system, the defects of which have been discussed elsewhere in this report.

The compounds of mills are frequently badly drained. Open drains, improperly graded and partially blocked by old sacks, etc., are a common feature; whilst quantities of discarded machinery and other scrap are usually to be found lying about the compound, and providing innumerable temporary breeding-places during the rains.

There are very large cellars underneath a number of the mills. In some cases these become flooded by surface water during the monsoon, and thus become favourable breeding-places. Other sources of mosquito breeding in connection with mills are fire-buckets and badly graded roof-gutters.

A dense population composed largely of the lowest classes live in the mill areas, their dwellings frequently abutting on the mill compounds. More favourable conditions for the propagation of malaria can scarcely be imagined.

As regards the cisterns, the general regulations which have been formulated in Chapter VI should render these innocuous. There is no technical reason why every cistern in every mill should not be rendered mosquito-proof, with the exception of the humidifier cisterns in the case of those mills in which a compressed air system is not installed for this purpose. These require to be cleaned out daily, and so are not a source of breeding, provided that the mill is working; but when for any reason

a mill is out of action they become a danger, as the orifice of the outlet pipe is usually placed some inches above the bottom of the cistern.

Dyeing vats also become potential breeding places when the mills are out of action, as being made of wood they have to be kept filled with water to prevent shrinkage. A third source of danger on such occasions is the presence of numerous small flush-cisterns in the water-closets, in which breeding may occur when they are not in daily use.

The treatment of the mill-ponds has been dealt with in Chapter VI. In the case of the dyeing works at Mahim Bay, however, in which larvæ of *A. stephensi* have at times been found, it is impossible for technical reasons to add either paris green or oil to the water in the pond ; and in this case it is necessary to keep the pond stocked with fish, and free from all vegetation and floating débris.

The principal anti-malarial measures recommended for use in mills may be shortly summarised as follows—

1. *General Measures*—

(*a*) **All cisterns and wells to be covered and rendered mosquito-proof** (see Chapter VI). **The automatic flush system in water-closets and urinals to be abolished.**

(*b*) **All mill-ponds to be treated weekly with paris green** (see Chapter VI).

(*c*) **Compounds of mills to be properly drained, drains to be well-graded, kept in good repair and not allowed to become choked. Drainage to be so arranged that any cellars which may exist may not be flooded during the rains.**

(*d*) **Collections of machinery and scrap to be so stacked that water cannot collect during the rains.**

(*e*) **Fire-buckets to be filled with sand ; or, if the Insurance Companies require them to be filled with water, some form of larvacide to be added to each bucket.***

(*f*) **Roof-gutters to be swept out on a specified day of each week throughout the rainy season.**

2. *Special Measures to be adopted when mills are not working*—

(*a*) **Humidifier cisterns, which must be provided with an outlet flush with the bottom of the cistern, to be emptied out completely.**

(*b*) **Some form of larvacide to be added to the water in each dyeing vat.**

(*c*) **Some form of larvacide to be poured into every water-closet flush cistern.**

It would, I think, be an advantage if posters embodying the above measures could be issued to each mill, with a request that a copy might be hung up in the office of the engineer in charge of the mill.

* I am informed by the Chief Officer, Bombay Fire Brigade, that the Insurance Companies do not object to the treatment of water in fire buckets with phenyle or similar fluids.

The Railways

There are very extensive areas in the Island of Bombay which come under the control of the B. B. & C. I. and G. I. P. Railways. Both lines run through the mill areas, and they present problems which are in the main very similar to those of the mills themselves.

There are in connection with the railways a number of large open or imperfectly protected cisterns; whilst a large proportion of the smaller covered cisterns in the railway stations and yards and in railway staff quarters are in a non-mosquito proof condition. As in the case of the mills, the pernicious automatic flush system above referred to is present in certain cases.

Certain of the yards contain acres of discarded machinery and scrap, usually stacked with no regard to the formation of collections of water during the rains, and thus providing numerous temporary breeding-places at that time of the year. Another source of breeding is the presence of open drains alongside the railway tracks which are frequently partially blocked or improperly graded The railway employees are frequently housed in quarters which are most unsuitable from the point of view of malaria control. For instance, in the case of the B. B. & C. I. tenements in DeLisle and Carroll Roads the spleen rate was found to be 55 per cent. and 42 per cent. respectively, a condition of things all the more significant in that regular medical attendance is provided. Both these sets of tenements adjoin a railway yard containing a very large imperfectly protected overhead cistern, many smaller cisterns which are not mosquito-proof, an open well and a number of boiler plates stacked in such a way as to allow the maximum amount of water to collect during the rains: whilst the former block has in addition a large overhead cistern for its own supply, with a non-mosquito proof corrugated iron cover. We have here a glaring example of a community of people whose health is year by year being seriously undermined by preventible conditions directly produced by the institution employing them.

There can be no doubt that the railways have contributed in no small degree to the serious incidence of malaria in the mill areas and elsewhere.

The general recommendations put forward in Chapter VI will, if they are adopted, deal with all the above mentioned points. But experience has shown that when defects are brought to the notice of the railway authorities either by their own Malaria Inspectors or by the Malaria Department of the Municipality there is frequently great difficulty and delay in getting them remedied; and even when action is taken, there appears to be a curious reluctance to carry out the work thoroughly. The cisterns on the roof of the Victoria Terminus station of the G. I. P. Railway form a case in point; some of the covers are corroded and have holes in them, but instead of being provided with new covers the holes are merely plugged with putty, so that constant inspection is required to see whether new holes have been formed.

It has been already mentioned that the Municipal Act is not applicable to the railways, and that therefore the Executive Health Officer of the Municipality has no powers to enforce the necessary measures of malarial prevention in the areas under their control. It is very necessary that the railway authorities, like every other public and private body in Bombay, shall be brought under the control of the Executive Health Officer for the purposes of sanitation. In the meanwhile, the **Agents of both the railways should be asked to give definite orders to their Executive Engineers (i) to fill in or hermetically cover every well in the railway areas, (ii) to render mosquito-proof every cistern in these areas in accordance with the regulations detailed in Chapter VI of this report, and (iii) to treat all requisitions from the Special Malaria Officer of the Municipality as matters of the most urgent importance.**

It may perhaps be mentioned here that it will handsomely pay the railway authorities to adopt similar measures, particularly with regard to the mosquito-proofing of cisterns, not only in Bombay but in all the stations on their lines, if only to safeguard the health of their employees.

Outbreaks of Malaria on Ships

This problem is one of such great importance in the case of Bombay that no apology is needed for discussing it in detail.

During the epidemic of 1908, the crews of many of the P. and O. vessels moored in the most southerly berths of the Victoria Dock contracted malaria. Bentley records that on boat after boat from 80 to 100 cases of the disease occurred amongst the crew during the homeward voyage. It was only members of the crew who remained on board whilst the ships were in the Dock who suffered; the passengers entirely escaped. Other ships berthed in the more northern portion of the Dock and in Prince's Dock were apparently unaffected.

At this period the Alexandra Dock, which lies immediately to the south of the Victoria Dock was in the course of construction, and a large number of labourers were employed, many of whom were quartered in huts erected on the site of the works. As we have seen, the conditions obtaining during the construction of the Dock were in a large measure responsible for the outbreak of 1908, and there can be little doubt that the malaria occurring on the ships at this period was chiefly if not entirely due to this cause.

In the autumn of 1922 there were again a large number of cases of malaria recorded on several of the P. and O. ships, which were now berthed in the Alexandra Dock, this having been completed in 1914. The cases all occurred on board ships which had been moored in the three most southerly berths in this Dock. In the case of the "Caledonia," which was the ship most affected, and which lay in berth No. 3, it was stated that 80 per cent. of the cases occurred amongst members of the crew quartered on the side of the vessel which lay against the quay whilst in the Dock.

Lieut.-Colonel Christophers, who conducted an inquiry into the circumstances of the outbreak, was of opinion that the principal cause

was probably the breeding of Anopheline mosquitoes in the cisterns on the roof of St. George's Hospital and of other large buildings in the vicinity.

In 1924 there were again cases of malaria on board ships in the Docks, the vessels affected being those which had been moored in No. 2 berth of Alexandra Dock and Nos. 4 and 5 in Victoria Dock. This outbreak was investigated by Lieut.-Colonel Houston, the Port. Health Officer, who pointed out that the cisterns on the roof of Ste George's Hospital could not in this instance be blamed, as they were now all mosquito-proof. He considered the outbreak to be due to diffusion of nfectd Anopheline mosquitoes from the neighbouring houses in Fort Northe where malaria was very rife at the time, and from which the wind b,lew directly on to the Dock during the monsoon. He admitted, however, that this explanation did not satisfactorily account for the cases occurring on the ships moored in Victoria Dock.

During the present inquiry the Dock area and its surroundings have been investigated with particular care. It appears probable that none of the possible sources of danger can be held entirely responsible for the occurrence of malaria on the ships. In all probability the outbreaks were due to a combination of circumstances, which will now be discussed in detail. The area under consideration is shown in Map IV, p. 66.

1. *Infection from houses in Fort North and Mandvi—*

I agree with Colonel Houston as to the importance of Fort North as a source of infection. There are in all 329 wells in this Section of which 21 are completely uncovered and 203 are covered but are fitted with trap-doors, and are therefore dangerous potential breeding-places of *A. stephensi.* The cisterns in this Section of the City are also in a most unsatisfactory condition, a large proportion being non-mosquito proof. Moreover, as Colonel Houston pointed out, the wind during the monsoon months, blowing as it does directly from this locality on to the south-western corner of the Docks, must be an important factor in the diffusion of mosquitoes. It is significant also that the spleen census carried out during the present inquiry disclosed a serious focus of infection in Mandvi, immediately opposite Nos. 4 and 5 berths in Victoria Dock.

2. *The Ballard Estate—*

This is an area of reclaimed land situated due south of the Alexandra Dock, upon which large blocks of buildings, chiefly business premises, have been erected in recent years. Reinforced concrete enters largely into the construction of these buildings, and Colonel Christophers mentioned in his report that from 3,000 to 4,000 labourers were encamped on the site of the works. The enormous amount of Anopheline breeding which may occur during the construction of concrete buildings has been alluded to in Chapter III, and a very large number of these mosquitoes must have been produced on the Ballard Estate in this way. It appears exceedingly probable that the conditions obtaining on this Estate played a considerable part in connection with the outbreaks of malaria on the ships moored in the Alexandra Dock.

At the present time there are no buildings under construction in this area, but there are three cellars into which subsoil water percolates throughout the year, and at least ten others which are flooded when the level of the subsoil water rises during the monsoon. These constitute most dangerous breeding-places, and should be eliminated without delay. Measures for accomplishing this are laid down in Chapter VI.

3. *Victoria Terminus*—

Extensive works have been carried out in recent years in this locality, both in the station itself where new platforms and buildings have been constructed, and in the line running northward. I understand that formerly the coaches of the G. I. P. Railway used to be washed in the station, and that Anopheline breeding occurred there at all times of the year. It seems possible that this area, which lies immediately to the west of St. George's Hospital, has played a considerable part in the incidence of malaria among the hospital staff, and also on board the ships in the Docks.

The present remodelling scheme which is now nearing completion has greatly improved the drainage of the station, but there are still a number of cisterns, notably two which have just been installed in the railway guards' quarters, which are in a non-mosquito proof condition.

4. *St. George's Hospital*—

As has been already mentioned, the staff of this hospital suffered severely from malaria during the outbreak of 1908 and in the years immediately following. As the result of the occurrence of numerous cases amongst both the nursing staff and patients, a committee was appointed in 1914 to inquire into the matter. Conditions apparently improved during the following year, for a proposal to render one of the wards mosquito-proof was abandoned on the ground that malaria in the locality had greatly diminished. In 1922, however, complaints of malaria among the staff were again received, and in more recent years cases have continued to occur from time to time.

In the course of the present inquiry 36 children of the menial staff living in the hospital compound were examined, of whom 6 showed splenic enlargement and an equal number malaria parasites in the blood, the total number showing evidence of malarial infection being 22 per cent.

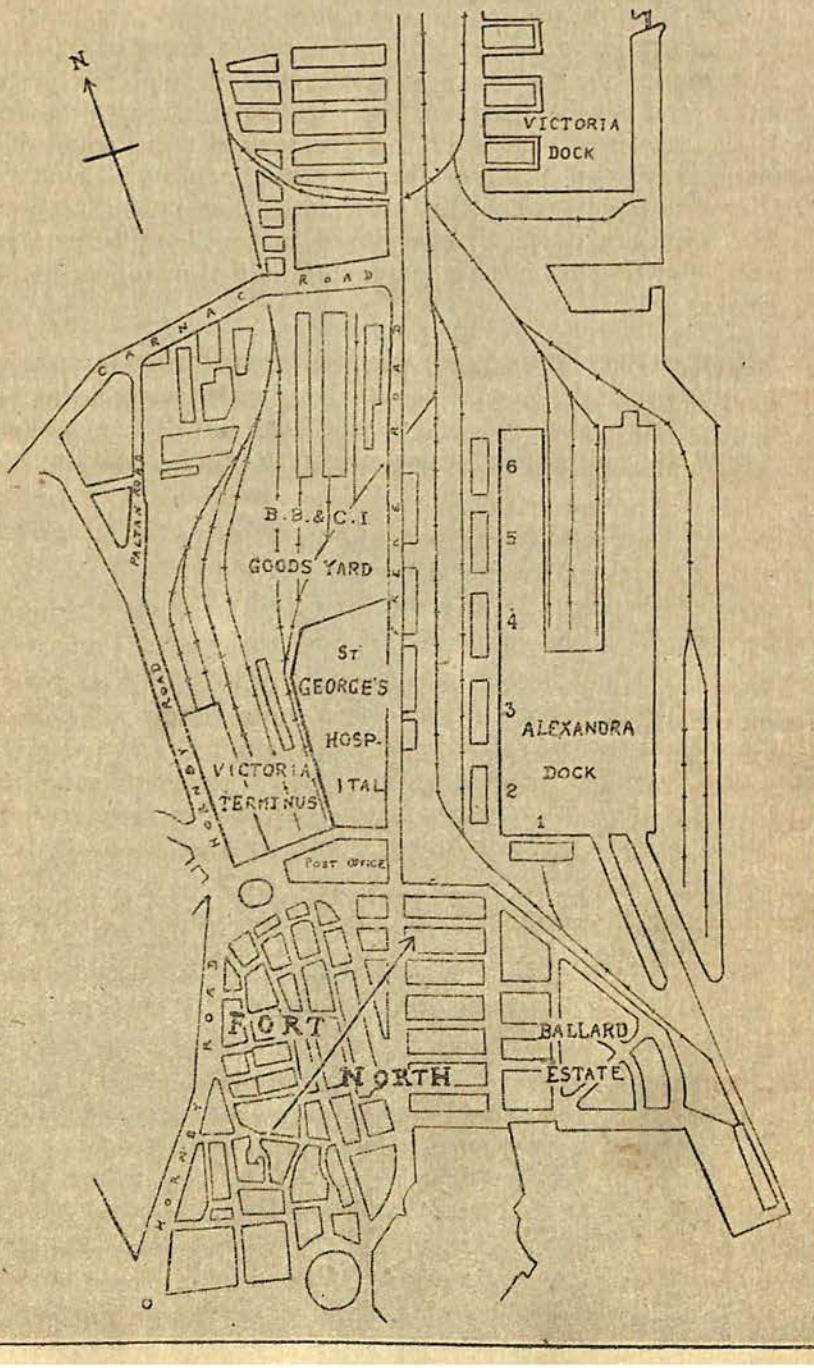
The numerous cisterns on the roof of the hospital and in the compound were rendered mosquito-proof in 1923, following Colonel Christophers' report. A detailed inspection of the hospital and compound made in the course of the present inquiry showed that these were still in a satisfactory condition, with the exception of one large cistern in the Nursing Sisters' quarters. The valve-box lid of this though secured with a bolt was ill-fitting, leaving a space nearly half an inch wide round the edge. The drainage of the dhobis' washing-places was defective, and collections of water were found in certain places on the terrace roof of the main building. Apart from these no other possible sources of Anopheline breeding were found either in the hospital or compound.

Map IV.

MAP OF ALEXANDRA DOCK AND ENVIRONS

THE FIGURES INDICATE NUMBERS OF BERTHS

THE ARROW SHOWS THE DIRECTION OF THE WIND DURING THE MONSOON.



5. *The Docks*—

There are numerous cisterns in the Alexandra Dockyard, but they are all mosquito-proof. There is a Malaria Inspector with a staff which is employed solely for anti-malarial work. Except possibly for the chance of breeding occurring during the monsoon in the roof-gutters, the Docks may be ruled out as factors in the incidence of malaria on ships in Bombay. If this were due to conditions in the Docks the disease would be general, and not confined to the three most southerly berths.

6. *Barges and Country Boats*—

Although, as is noted elsewhere, these are responsible for a great deal of the " mosquito nuisance " on board the ships in the Docks, it is very unlikely that they play any part in the dissemination of malaria. The mosquitoes breeding in the water casks are as far as can be ascertained exclusively Culicines, and if these craft played any part in the incidence of malaria the effect would be apparent all over the Docks, and not in any special quarter.

7. *The B. B. & C. I. Railway Goods Yard, Carnac Bunder*—

This lies immediately to the north of St. George's Hospital, and to the north-east of the berths where the infected ships lay in the Alexandra Dock. No permanent breeding-places were found in this yard, and of 36 children living in it only three showed enlargement of the spleen. The spleen rate amongst the children living in the Municipal tenements in Paltan Road, which adjoin the yard, was only three per cent. This area may I think be ruled out as a possible source of danger, at any rate at the present time.

At the present time there is not a serious amount of endemic malaria in the immediate vicinity of the Alexandra Dock. The adoption of the general measures of prevention laid down in Chapter VI will abolish all permanent breeding-places of *A. stephensi* in the neighbourhood, and I feel confident that if they are systematically carried out, there will be no outbreaks of malaria on the ships in the Docks in future.

The Breeding of Anopheline Mosquitoes in Salt and Brackish Water

The fact that Anopheline mosquitoes will breed in sea-water has been known for many years. Of the species occurring in India the following have been recorded as having been found breeding in salt or brackish water :—

A. ludlowii.
A. stephensi.
A. subpictus.
A. vagus.
A. culicifacies.
A. barbirostris.
A. fuliginosus.
A. hyrcanus var *nigerrimus.*
A. umbrosus.

Of these, however, only one, *Anopheles ludlowii*, can be classed as a natural salt-water breeder. The others are all fresh-water breeders by nature, and the presence of their larvæ in salt water may be regarded as only an occasional phenomenon.

In Bombay, Gholap recorded the breeding of *A. stephensi* in salt water pools at Colaba in 1910. Bentley also noted that this species will breed in salt water, but he found that if larvæ which had hatched out in fresh water were transferred to salt water, they quickly died. Chalam confirmed this observation, and in addition to *A. stephensi* has recorded the finding of larvæ of *A. subpictus*, *A. vagus* and *A. culicifacies* in salt water pools in connection with the reclamation works at Back Bay. The last two species mentioned were only met with very occasionally.

In the annual reports of the Executive Health Officer, frequent references are to be found to the breeding of Anopheline mosquitoes in pools on the foreshore opposite Nepean Sea Road, and at one period (1912-1915) the question of reclaiming this area as an anti-malarial measure was under consideration.

As regards Back Bay, all the foreshore pools now remaining in the reclamation area are washed out twice daily by the neap-tides, and so need not be considered as sources of breeding.

The breeding of Anopheline mosquitoes, however, still goes on in certain pools on the foreshore in the neighbourhood of Malabar Hill, larvæ of both *A. stephensi* and *A. subpictus* being found. These breeding-places have been closely studied during the present inquiry, and it has been found that larvæ are only present in certain particular situations, these being in the immediate neighbourhood of fresh water pools formed by springs or seepages from the side of the hill. These pools contain a varying proportion of sea water, and there are only a limited number in which larvæ are to be found. The positions of these have been marked down, and it is a simple matter for the malaria staff to oil them in the intervals between the spring-tides.

I do not consider that the breeding of Anopheline mosquitoes in salt water need be taken into account as a serious factor in the production of malaria in Bombay. If this were so there would be a high incidence of the disease all round the coast of the island, wherever any pools exist which are not washed out by the neap-tides, as is the case in places where *A. ludlowii* occurs. It is fortunate indeed that this notorious malaria-carrier does not exist on the Bombay coast. As it is, we have seen that Dharavi village, for instance, which is situated within a few yards of a mangrove swamp, is almost entirely free from malaria.

The occurrence of cases of malaria in the neighbourhood of Nepean Sea Road and Warden Road is much more likely to be due to breeding in the masonry tanks and fountains in the gardens than to breeding of Anophelines in the foreshore pools.

The Control of Malaria in Labour Camps

Allusion has been made in Chapter II to the very serious effect on the incidence of malaria which may result from the presence of aggregations

of labourers in connection with the construction of reclamation works, dockyards and similar enterprises, and we have seen that many examples of outbreaks due to this cause have occurred from time to time in the history of malaria in Bombay.

Similar instances might be quoted from almost every country in the tropics in which the disease is prevalent; and in Bombay the danger of malaria epidemics should invariably be borne in mind when any large works such as the erection of new tenement blocks, reclamation works, railway construction, etc., are contemplated either by public or by private bodies.

The Special Malaria Officer should be informed whenever such works are to be undertaken, and if the body of labourers to be employed is very large, a special medical officer should be detailed to look after their health; otherwise the work might be undertaken by the Malaria Inspector of the Ward in which the work is being carried out. **Labour camps should never be situated on the actual site of the works.** The labourers and their families should be inspected at the outset, as also all subsequent arrivals in the camps. All persons, and especially all children, found to have enlargement of the spleen or malaria parasites in their blood, should receive a course of treatment by quinine; and all cases of malaria occurring in the camps should receive efficient treatment under careful supervision.

The Military Area, Colaba

Records of cases treated for malaria amongst British Troops stationed in Bombay for a number of years are given in Appendix D, Table V. It is difficult to draw precise conclusions from these figures, owing to the fact that units may be transferred to Bombay at any time from highly malarious stations. It is however significant that in spite of a diminished incidence of the disease during the last two years, which as we have seen has been general all over the island, the average ratio of admissions for malaria per thousand of British Troops since 1922 has been at least as high as it was during any similar period between 1896 and 1909. It would appear to be an undoubted fact that cases of fresh infection amongst the troops do occur in Bombay. These have been attributed to infections contracted outside the military area, but I understand that during a period when all troops were confined to the Lines on account of an outbreak of cholera fresh cases of malaria continued to occur.

The situation of the Lines is a most excellent one from the point of view of malarial control, and here if anywhere in Bombay it should be feasible to prevent all possibility of the occurrence of fresh infections. An inspection of the area has however shown that there is considerable room for improvement in the matter of antimalarial measures.

The great object to be aimed at is to render every well and cistern in the area absolutely mosquito-proof by the adoption of permanent measures.

1. WELLS—

There are 12 wells in the area, and I understand that none of them are required for use. Some of these are completely covered with concrete,

but others have a circular portion in the centre of the cover which is apparently made of zinc. These circular metal portions have been cemented down, but I was shown one in which the cement had become loosened. There is not the slightest doubt that the others will eventually get into a similar condition, and will form a dangerous source of breeding. **I recommend that every cover of this nature be immediately removed and replaced by a concrete cover, so that every well in the area is permanently hermetically sealed.**

2. CISTERNS—

There are 208 cisterns in the area, and some at least of them are by no means mosquito-proof. One in particular, situated in the cemetery, had a valve-box lid which was corroded to such an extent that it was possible to put one's hand through it without opening it. In other cases man-hole lids were ill-fitting, inlet pipes unprovided with checknuts, and overflow pipes and ventilators uncovered.

I understand that the antimalarial squad go round the cisterns armed with putty with which they endeavour to render the man-hole and valve-box lids mosquito-proof. This should be entirely unnecessary, and I strongly recommend that all the measures which have been laid down with regard to cisterns in Chapter VI of this report be carried out without delay throughout the military area. **In particular, cisterns should be numbered in series, valve-boxes abolished, all rectangular man-hole lids replaced by circular cap-covers, all lids kept locked, inlet-pipes provided with checknuts and warning pipes with brass caps.** With so few cisterns to look after, it should be possible for the Officer in charge of antimalarial measures to inspect each of these dangerous sources of mosquito breeding personally every month.

With regard to other possible sources of breeding, drains leading from stand-pipes should be kept clean and free from overhanging vegetation, and a watch kept on any of the foreshore pools which are not washed out daily by the neap-tides.

In understand that difficulty is sometimes experienced in getting the Engineering staff to attend to necessary antimalarial measures. As in the case of the Railways and other bodies in Bombay, instructions should be issued to the Officers concerned to treat all requisitions with regard to the prevention of malaria as matters of urgent importance.

In the case of troops arriving from a malarious station, an important source of human infection is provided by the presence of the menial staff and their families. **These should be regularly inspected, and any cases of malaria especially amongst the children, who form the chief reservoir of infection, should receive systematic treatment under careful supervision.**

CHAPTER VIII

ANTIMALARIAL LEGISLATION

The Existing Law

The following are extracts from those sections of the City of Bombay Municipal Act which are of importance in relation to malaria prevention :—

Section 3.
Definition of terms.

(*t*) "*Water work*" includes a lake, stream, spring pump, reservoir, cistern, tank, duct, whether covered or open, sluice, mainpipe, culvert, engine and any machinery, land, building or thing for supplying or used for supplying water.

(*z*) "*Nuisance*" includes any act, omission, place or thing which causes or is likely to cause injury, danger, annoyance or offence to the sense of sight, smelling or hearing, or which is or may be dangerous to life or injurious to health or property.

(*aa*) "*Dangerous Disease*" means cholera and any endemic, epidemic or infectious disease by which the life of man is endangered.

Section 61.
Matters to be provided for by the Corporation.

It shall be incumbent on the corporation to make adequate provision, by any means or measures which is lawfully competent to them to use or take, for each of the following matters, namely :—

(*d*) The reclamation of unhealthy localities, the removal of noxious vegetation and generally the abatement of all nuisances.

(*g*) Measures for preventing and checking the spread of dangerous diseases.

Section 64.
Special functions of the Commissioner.

(3) Subject, whenever it is in this Act expressly so directed, to the approval or sanction of the corporation or the standing committee and subject also to all other restrictions, limitations and conditions imposed by this Act, the entire executive power for the purpose of carrying out the provisions of this Act vests in the Commissioner.

Section 68.

Municipal officers may be empowered to exercise certain of the powers of the Commissioner.

(1) Any of the powers, duties or functions conferred or imposed upon or vested in the Commissioner by any of the sections, sub-sections or clauses mentioned in sub-section (2) may be exercised, performed or discharged, under the Commissioner's control and subject to his revision and to such conditions and limitations, if any, as he shall think fit to prescribe, by any municipal officer whom the Commissioner generally or specially empowers in writing in this behalf; and in each of the said sections, sub-sections and clauses the word "Commissioner" shall, to the extent to which any municipal officer is so empowered, be deemed to include such officer.

(2) The sections, sub-sections and clauses of this Act referred to in sub-section (1) are the following, namely:—

279, 374, 377, 381, 381A, 488, 489.

Section 274.

Provisions as to cisterns.

(1) The Commissioner may, whenever it shall appear to him to be necessary, by written notice require that any premises furnished with a private water-supply from any municipal water-work shall, within a reasonable period, which shall be prescribed in the said notice, be provided with a storage cistern of such size, material, quality and description, and with such fittings and placed in such a position and with such means of access as he thinks fit.

Section 279.

Power to cut off private water-supply or to turn off water.

(1) The Commissioner may cut off the connection between any municipal water-work and any premises to which a private water-supply is furnished by the corporation or turn off the water from such premises in any of the following cases, namely:—

(*b*) if the owner or occupier of the premises neglects, within the period prescribed in this behalf in any notice given under sub-section (1) of section **274**, to comply with any requisition made to him by the Commissioner regarding the provision of a storage-cistern, or the means of access thereto. Provided that....the Commissioner shall not take action without the sanction of the standing committee.

Section 374.

Power to inspect premises for sanitary purposes.

The Commissioner may inspect any building or other premises for the purpose of ascertaining the sanitary condition thereof. (But see Section **488**.)

Section 377.
Neglected premises.

If it shall appear to the Commissioner that any premises are overgrown with rank and noisome vegetation or are otherwise in an unwholesome or filthy condition, or, by reason of their not being properly enclosed are resorted to by the public for purposes of nature, or are otherwise a nuisance to the neighbouring inhabitants, the Commissioner may, by written notice, require the owner or occupier of such premises to cleanse, clear or enclose the same, or, with the approval of the standing committee, may require him to take such other order with the same as the Commissioner thinks necessary.

Section 381.
Filling in of pools, etc., which are a nuisance.

(1) If in the opinion of the Commissioner—

(*a*) any pool, ditch, tank, well, pond, quarry-hole, drain, water-course, or any collection of water, or

(*b*) any cistern or other receptacle for water whether within or outside a building, or

(*c*) any land on which water accumulates and which is situate within a distance of one hundred yards from any building used as a dwelling-house,

is or is likely to become a breeding place of mosquitoes or in any other respect a nuisance, the Commissioner may, by notice in writing, require the owner thereof to fill up, cover over or drain off the same in such manner and with such materials as the Commissioner shall prescribe, or to take such order with the same for removing or abating the nuisance as the Commissioner shall prescribe.

(2) If an owner, on whom a requisition is made under sub-section (1) to fill up, cover over or drain off a well, delivers to the Commissioner, within the time prescribed for compliance therewith, written objections to such requisition, the Commissioner shall report such objections to the standing committee, and shall make further inquiry into the case, and he shall not institute any prosecution under section **517** for failure to comply with such requisition except with the approval of the standing committee, but the Commissioner may nevertheless, if he deems the execution of the work called for by such requisition to be of urgent importance, proceed in accordance with section **489** and, pending the standing committee's disposal of the question whether

the said well shall be permanently filled up, covered over or otherwise dealt with, may cause such well to be securely covered over, so as to prevent the ingress of mosquitoes, and in every such case the Commissioner shall determine, with the approval of the standing committee, whether the expenses of the work already done as aforesaid shall be paid by such owner, or by the Commissioner out of the municipal funds, or shall be shared, and if so, in what proportion.

Section 381A.
Permission for new well, etc.

(1) No new well, tank, pond, cistern or fountain shall be dug or constructed without the previous permission in writing of the Commissioner.

(2) If any such work is begun or completed without such permission, the Commissioner may either—

(*a*) by written notice require the owner or other person who has done such work to fill up or demolish such work in such manner as the Commissioner shall prescribe, or

(*b*) grant written permission to retain such work, but such permission shall not exempt such owner from proceedings for contravening the provisions of sub-section (1).

Section 461.
By-laws, for what purposes to be made.

The corporation may from time to time make by-laws, not inconsistent with this Act, with respect to the following matters, namely :—

(*a*) regulating, in any particular not specifically provided for in this Act, the construction, maintenance and control of drains, ventilation-shafts or pipes, cess-pools, water-closets, privies, latrines, urinals, drainage-works of every description, whether belonging to the corporation or to other persons, municipal water-works, private communication-pipes and public streets ;

(*b*) regulating all matters and things connected with the supply and use of water.

Section 471.
Certain offences punishable with fine.

Whoever

(*a*) contravenes any provision of any of the sections, sub-sections or clauses mentioned in the first column of the following table, or of any regulation made thereunder ; or

(*b*) fails to comply with any requisition lawfully made upon him under any of the said sections, sub-sections or clauses ;

shall be punished, for each such offence, with

fine which may extend to the amount mentioned in that behalf in the third column of the said table.

Section, sub-section or clause	Subject	Fine which may be imposed
		Rs.
Section 274 ..	Requisition to provide storage cisterns and other fittings to be used for connections with water-works.	50
Section 377 ..	Requisition to cleanse, etc., neglected premises.	50
Section 381 ..	Requisition to fill in pools, etc., which are a nuisance.	50
Section 381A, sub-section (1).	Digging or constructing well, etc., without permission.	50
Section 381A, sub-section (2).	Requisition to fill in or demolish well, etc.	50

Section 472. Continuing offences.

Whoever, after having been convicted of

(*a*) contravening any provision of any of the sections, sub-sections or clauses mentioned in the first column of the following table, or of any regulation made thereunder, or,

(*b*) failing to comply with any requisition lawfully made upon him under any of the said sections, sub-sections or clauses,

continues to contravene the said provision or to neglect to comply with the said requisition, or fails to remove or rectify any work or thing done in contravention of the said provision, as the case may be, shall be punished for each day that he continues so to offend, with fine which may extend to the amount mentioned in that behalf in the third column of the said table.

Section, sub-section or clause	Subject	Daily Fine which may be imposed
		Rs.
Section 377 ..	Regulation to cleanse, etc., neglected premises.	5
Section 381 ..	Requisition to fill in pools, etc., which are a nuisance.	5
Section 381A, sub-section (2).	Requisition to fill in or demolish well, etc.	5

Section 488.
Power of entry.

The Commissioner may enter into or upon any building or land, with or without assistants or workmen, in order to make any inspection or survey or to execute any work which is authorised by this Act or by any regulation or by-law framed under this Act to be made or executed, or which it is necessary for any of the purposes, or in pursuance of any of the provisions, of this Act or of any such regulation or by-law, to make or execute.

Provided that—

(*a*) except when it is in this Act otherwise expressly provided, no such entry shall be made between sunset and sunrise;

(*b*) except when it is in this Act otherwise expressly provided, no building which is used as a human dwelling shall be so entered, unless with the consent of the occupier thereof, without giving the said occupier not less than twenty-four hours' previous written notice of the intention to make such entry, and unless for any sufficient reason it shall be deemed inexpedient to furnish such information, of the purpose thereof;

(*c*) sufficient notice shall in every instance be given, even when any premises may otherwise be entered without notice, to enable the inmates of any appartment appropriated to females to remove to some part of the premises where their privacy need not be disturbed;

(*d*) due regard shall always be had, so far as may be compatible with the exigencies of the purpose for which the entry is made, to the social and religious usages of the occupants of the premises entered.

Section 489.
Enforcement of orders to execute works, etc.

(1) When any requisition or order is made, by written notice, by the Commissioner or by any municipal officer empowered under section **68** in this behalf, under any section, sub-section or clause of this Act mentioned in sub-section (2), a reasonable period shall be prescribed in such notice for carrying such requisition or order into effect, and if, within the period so prescribed, such requisition or order or any portion of such requisition or order is not complied with, the Commissioner may take such measures or cause such work to be executed or such thing to be done as shall, in his opinion, be necessary for giving due

effect to the requisition or order so made, and, unless it is otherwise in this Act expressly provided, the expenses thereof shall be paid by the person or by any one of the persons to whom such requisition or order was addressed.

(2) The sections, sub-sections and clauses of this Act referred to in sub-section (1) are the following, namely :—

377, 381, 381A.

(3) The Commissioner may take any measure, execute any work or cause anything to be done under this section, whether or not the person who has failed to comply with the requisition or order is liable to punishment or has been prosecuted or sentenced to any punishment for such failure.

Section 517.
Legal proceedings.

(1) The Commissioner may—

(*a*) take, or withdraw from, proceedings against any person who is charged with—

(*i*) any offence against this Act;

(*ii*) any offence which affects or is likely to affect any property or interest of the corporation or the due administration of this Act;

(*iii*) committing any nuisance whatsoever.

Section 518.
Power to Government to provide for performance of duties in default of any municipal authority.

(1) If, upon complaint being made to him and after such inquiry as he thinks fit to make, it shall at any time appear to the Governor in Council that any of the provisions of sections **61**, ..., have not been or are not being duly carried out or enforced, the Governor in Council may make an order prescribing a period within which such provision shall be carried out or enforced:

(2) Provided that, except in any case which appears to the Governor in Council to be one of emergency, no such order shall be made until after the expiry of one month from the date of service of a written notice on the corporation, and, if the Governor in Council shall think fit, on the Commissioner, requiring cause to be shown why such order should not be made, nor until the cause, if any, so shown has been considered by the Governor in Council.

(3) If, within the period prescribed in an order made under sub-section (1) the provision is not carried out or enforced, the Governor in Council may appoint some person to carry out or enforce the same and may direct that the expense of carrying out or enforcing such provision, together

with such reasonable remuneration to the person carrying out or enforcing the same as the Governor in Council shall determine, and the cost of the proceedings under this section shall be paid out of the municipal fund.

Amendments now before the Government of Bombay

The following amendments of parts of the Municipal Act which are of importance with regard to antimalarial measures are at present awaiting the sanction of the Government of Bombay :—

Section 381. Filling in of pools, etc., which are a nuisance.

(*a*) For sub-section (1) the following sub-section shall be substituted, namely :—

(1) (*i*) For the purposes of this section, a nuisance shall include—

(*a*) any pool, ditch, tank, well, pond, quarry-hole, drain, watercourse or any collection of water, or

(*b*) any cistern, receptacle for water or any article or thing capable of containing water whether or not such cistern or receptacle, article or thing contains water and is within or outside a building, or

(*c*) any land on which water accumulates or is likely to accumulate, or

(*d*) any premises or part of any premises occupied or unoccupied, or under construction, reconstruction or demolition, which in the opinion of the Commissioner is, or is likely to become a breeding-place of mosquitoes or which is, in other respects, a nuisance as defined in clause (*z*) of section 3.

(*ii*) The Commissioner may, by notice in writing, require the person by whose act, default or sufferance, a nuisance arises, exists or continues, or is likely to arise, and the owner, lessee or occupier of the land, building or premises on which the nuisance arises, exists or continues or is likely to arise, or any one or more of such person, owner, lessee and occupier, to remove, discontinue or abate the nuisance by taking such measures and by executing such work in such manner with such materials as the Commissioner shall prescribe in such notice.

(*iii*) The Commissioner may also by any notice under clause (*ii*), or by another notice, served on such person, owner, lessee and occupier, or on any one or more of them, require them or any one or more of them to take all steps requisite or necessary to prevent a recurrence

of the nuisance, and may, if he thinks it desirable, specify any work to be executed or measures to be carried out for that purpose, and may serve any further such notice notwithstanding that the nuisance may have been abated or removed, if he considers that it is likely to recur:

Provided that if at any time within six months from the date of the service of any such notice, the nuisance recurs through the failure of the person or persons upon whom such notice has been served to comply with the requirements contained in such notice, such person or persons shall be liable without any further notice to the penalties provided in this Act for offences under this section.

(*iv*) Where the nuisance arises or exists or is likely to arise or recur in connection with the construction, reconstruction or demolition of any premises, or part of any premises, the Commissioner may in addition to serving any notice on any one or more of the persons mentioned in clause (*ii*) serve any such notice on any architect, contractor or other person employed to carry out such work of construction, reconstruction or demolition, and also on any sub-contractor employed by such contractor or other person, or any one or more of such contractor, person and sub-contractor.

(*b*) In sub-section (2)—

(*i*) for the words and figures "an owner, on whom a requisition is made under sub-section (1)" the words "any person who, by a requisition made under sub-section (1) is required" shall be substituted; and

(*ii*) for the word "owner" where it occurs for the second time, the word "person" shall be substituted.

Section 471.
Penalties.

In the table to this section,

(2) in column 3 of the entries relating to section **381A,** sub-section (1), and section **381A,** sub-section (2), for the word "fifty" the words "five hundred" shall be substituted.

Section 472.
Continuing offences.

In the table to this section,

in column 3 of the entries relating to section **381,** and section **381A,** sub-section (2), for the word "five" the word "fifty" shall be substituted.

These amendments will considerably strengthen the existing Act by increasing the penalties for non-compliance with the most important sections from the point of view of malaria prevention, and by providing explicitly for dealing with breeding-places produced during building operations. I understand that they have been before the Government of Bombay for the last three years, and it is to be hoped that they will finally become law in the near future.

Further Amendments now suggested

1. *The Municipal Act.*

It appears that all the recommendations put forward in Chapter VI of this report can be enforced without alteration in the existing law, in so far as private individuals and firms are concerned, with the possible exception of that relating to the keys of domestic cisterns being kept by the Malaria Department. It has been emphasised, however, that some of the greatest difficulties of the Department have arisen in dealing with Railways, Government Departments, and other public bodies, and stress has been laid on the necessity for bringing these bodies under the control of the Executive Health Officer for purposes of sanitation.

It will be necessary for the whole scheme which has been detailed in the preceding pages to be laid before the Government Solicitors, in order that they may advise as to the framing of any amendments which may be necessary to put it into effect.

In any case, I recommend the following alterations in the existing Act :—

(*a*) Section **274** should be added to the list of sections named in section **489,** in order to enable the Municipality to provide access to cisterns at the owner's expense in the event of his failure to comply with orders.

(*b*) The clumsy sub-section (2) of section **381,** which has been responsible for so much delay in carrying out necessary measures of malaria control, and which appears to invite objections on the part of owners of wells, should be deleted from the Act.

(*c*) In order further to strengthen sections **381,** and **381A,** which are of vital importance to the successful working of the scheme, these two sections should be included in the list given under section **518,** which has been quoted above.

2. *The Indian Ports Act.*

As regards the proposals put forward for dealing with mosquito-breeding on board cargo-boats and barges in the Docks, the **Government Solicitors should similarly be asked to frame any amendments to the Indian Ports Act which may be necessary** to put them into force. Until this is done, Bombay will retain her reputation of being the worst port for mosquitoes in the East, and it is earnestly hoped that any alterations required in the Act may be passed with the least possible delay.*

* I understand that certain amendments to this Act, designed to mitigate mosquito-breeding, have been under the consideration of the Government of Bombay since the year 1922.

CHAPTER IX

THE COST OF MALARIA AND OF ITS PREVENTION IN BOMBAY

The Present Cost of Malaria in Bombay

To estimate the annual cost of malaria in a City like Bombay with even approximate accuracy is an extremely difficult task. Bentley calculated that the amount lost each year to the City on account of this disease was at a low estimate somewhere between 12 and 13 lakhs of rupees.

He based his figures on those representing the incidence of malaria amongst the City Police, on the assumption that the general population of Bombay suffers from the disease to at least as great an extent. Now, the average number of cases of "fever" recorded amongst the Police for the years 1921 to 1927 was 3,957, whilst the average sanctioned strength of the force during these years was 3,403. If we reckon that 75 per cent. of these cases were malaria (and it is probable that this estimate is too low), we obtain a figure of 872 per thousand of strength per annum. If the assumption that the general population of Bombay suffers as much from malaria as do the Police is correct, then there are about 11,30,000 cases of malaria in the City every year. Nearly 70 per cent. of the population are classed as workers, so that we may assume that there are on an average over 650,000 malarial attacks amongst these during the year. Taking the average monthly earning of each worker at Rs. 30 (a very low estimate), and assuming that each attack entails the loss of one week's work, we arrive at a total of Rs. 48,75,000 as the amount lost annually either in wages to the worker or in loss of work to the employer. This is at first sight an astonishing figure, and may be thought to be too high; but when we add the expenditure on medical aid for both workers and non-workers, the loss suffered by private individuals who have to leave the City or send away members of their family to recover their health, the loss occasioned to business firms by the disorganisation of their staff, and the amount expended on antimalarial measures, we are I think justified in estimating the average annual cost of malaria in Bombay at the present time at not less than 50 lakhs of rupees.

The amount budgeted for the year 1928-29 for the expenditure of the Malaria Department of the Municipality was Rs. 1,75,802, of which Rs. 1,59,336 comes under the head of "establishment". The Port Trust and the Development Department have each spent on an average about Rs. 28,000 per annum on antimalarial work during the past five years, whilst the G.I.P. Railway and B.B. & C.I. Railway incur an annual expenditure of approximately Rs. 6,000 and Rs. 4,000 respectively on this account. The last two figures do not include the cost of any works such as filling in of depressions in the ground, etc.

An attempt was made to ascertain the average number of working days lost annually from sickness or sick leave on account of malaria

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amongst employees of various public bodies, but figures were only available in the case of the B.B. & C.I. Railway and the Port Trust. In the former case an average of about 25,000 working days has been lost annually for the last five years amongst employees in the island of Bombay on account of the disease. In the case of the Port Trust the average number of days lost annually during the same period has been 12,424, excluding periods of sick leave granted directly by heads of departments, or on the certificates of private medical practitioners.

As regards certain other bodies, the average number of employees treated annually for malaria during the last five years at the G.I.P. Railway dispensaries in Bombay was 10,528, and at the City Improvement Trust dispensary 2,007.

Unfortunately it is impossible to obtain any figures as to the number of working days lost or the number of cases treated for malaria amongst the mill-hands, who form by far the most numerous class of workers in Bombay, and who live for the most part in the most malarious quarters of the City. The figures given above do, however, give some indication of the very large amount of financial loss caused to Bombay by the prevalence of the disease.

The Cost of the Measures now Advocated

1. *The Cost to the Municipality—*

(*a*) *Expenditure on Cisterns—*

The provision of locks, the numbering of cisterns, and the rendering mosquito-proof of all the cisterns under the control of the Municipality will probably cost not less than Rs. 50,000.

(*b*) *Expenditure on Wells—*

The Municipal Commissioner has power under the Municipal Act to require owners of wells to fill in or cover them up, or failing compliance to cause the necessary work to be done and to recover the cost from the owners.

There are in the whole island 898 open wells and 1,531 wells with trap-doors. The cost of covering the former will range up to about Rs. 500 each for the largest wells, whilst in the case of wells with trap-doors it will only be Rs. 2 or Rs. 3 each. The cost of covering all the wells in the island will probably be in the neighbourhood of three lakhs of rupees, and it is a matter for consideration as to what proportion, if any, of this will be borne by the Municipality.

(*c*) *Expenditure on other measures—*

It is very difficult to give any figures for the cost of other measures recommended, such as the provision of cement drains for stand-pipes, etc. These measures do not appear in any case to involve very large expenditure, and it is estimated that Rs. 50,000 will cover the total cost.

2. *The Cost to the Millowners—*

Here again only approximate figures can be given. The principal expenditure will be involved in the covering of the large overhead cisterns.

These vary very much in size, but an idea of the cost can be gained from the fact that the total expenditure incurred in covering nine cisterns in the case of the E. D. Sassoon group of mills was Rs. 4,925.

It is estimated that the average cost of the measures recommended will be about Rs. 3,000 per mill. In addition, the cost of treating the mill-ponds regularly with paris green will be about Rs. 160 per annum for each mill.

3. *The Cost to the Railways—*

As in the case of the mills, the principal item of expenditure will be in connection with the large overhead cisterns. There are altogether 40 cisterns in the railway areas which are either open altogether or have corrugated iron covers. It is estimated that the total cost of rendering all the cisterns in the railway areas mosquito-proof will be in the neighbourhood of Rs. 50,000 or Rs. 60,000 for each of the railways concerned.

There can be no question, at least for many years, of reducing the personnel of the Malaria Department of the Municipality, or of the malaria staffs employed by various other bodies in Bombay. Thus it is estimated that for the control of malaria over the whole of the island there is required a capital expenditure of approximately Rs. 8,00,000, and an annual expenditure of approximately Rs. 2,00,000. In view of the fact that the annual cost of malaria to the City is estimated to be in the neighbourhood of 50 lakhs of rupees, this sum cannot be regarded as excessive.

I wish to emphasise here that unless the permanent measures of control which I have advocated are carried out, a very large increase in the personnel of the Malaria Department will be necessary, which will at least double the present annual expenditure under this head.

CHAPTER X

THE NEED FOR CO-OPERATION

Allusion has frequently been made in the course of this report to the difficulties and delays encountered by the Malaria Department in getting necessary measures of malaria prevention carried out in the case of Railways, Government Departments and other public bodies, and of the Municipality itself. The apparent apathy and lack of interest in the subject of malaria control on the part of the Chief Officers concerned are I think principally due to ignorance of the true position with regard to malaria in general, and to conditions in Bombay in particular.

Malaria, unlike certain other diseases such as cholera and plague, does not destroy its victims with dramatic suddenness, and unless it flares up in epidemic form its full effects are not apparent to the layman, who does not appreciate the paralysing influence which the disease exerts upon trade, and the resultant debility which renders those suffering from it a ready prey to other diseases.* There is, besides, an unfortunate tendency to take up the attitude that because malaria is widespread throughout India, and because it has always been present in Bombay, therefore it will always exist, no matter what one does to prevent it. In certain cases the heads of departments appear to look upon the disease as a necessary evil, and to regard the measures advocated for its control as of but little importance.

The usual reason given for non-compliance with the requisitions of the Special Malaria Officer is that funds are not available. If Bombay is to tackle the malaria problem seriously, it should not be possible for a requisition to deal with a dangerous source of breeding, involving trifling expenditure, to be turned down on this account.

The heads of commercial firms, such as those controlling tea plantations or rubber estates, are always quick to see that money spent on antimalarial measures represents a profitable business proposition, and **if the whole of Bombay were administered on business lines by a single authority there is little doubt that endemic malaria would have been stamped out in the island long ago.** The fact that so many different bodies control various areas in the island has seriously militated against the success of preventive measures, one of the chief reasons being the feeling on the part of one or other authority that its neighbours were not doing their fair share of the work, or bearing their just proportion of the cost.

It has been pointed out that the Municipal Act does not apply to the Railways and Government Departments, and it has been urged that legislation should be passed to bring these bodies under the Act for the purposes of sanitation. But even if this is brought about, the necessary measures will never be carried out promptly and effectively without the active co-operation of the officers controlling these bodies, and of the Municipality itself, which is not the least of the offenders.

* It is not generally known that the average annual number of deaths from Malaria in India is estimated to be approximately 1¼ millions.

It is of the utmost importance that the Chief Officers of the bodies concerned shall realise—

(1) that malaria is a very serious source of loss of revenue to Bombay ;

(2) that their own failure to ensure that the necessary measures of control are carried out is very largely responsible for the serious damage caused by the disease to the health of their employees ;

(3) that the disease is easily preventible by systematically attacking the breeding-places of a single species of mosquito which is the agent for its transmission in Bombay ;

(4) that an unprotected source of breeding of this mosquito is an *immediate* danger, and that every day's delay in dealing with it means that the health of the persons living in the vicinity is menaced ;

(5) that the money spent on antimalarial measures will be amply repaid by results.

I recommend that the Government of Bombay shall address the Municipality, the Chief Officers of all Government Departments and other public bodies in Bombay, the Agents of the B.B. & C.I. and G.I.P. Railways and the President of the Mill-owners' Association, requesting that in each case definite instructions shall be given to the Executive Engineers concerned—

(1) that the recommendations laid down in Chapter VI of this report shall be carried out with the least possible delay ;

(2) that in future all requisitions from the Special Malaria Officer of the Municipality shall be treated as matters of the most urgent importance, and

(3) that the execution of such requisitions shall in no case be delayed without immediate reference to the Chief Officer of the body concerned.

It is particularly necessary that engineers in charge of water works should realise that from the point of view of the health of the City it is as important for a cistern to be mosquito-proof as that it should not have a hole in the bottom.* If this principle had been followed in the past, it would for instance have been impossible for the automatic flush system at present existing in many of the public water-closets in the streets, mill-componds and railway areas in Bombay to have been introduced.

The Malaria Advisory Committee

The Malaria Advisory Committee was brought into existence with the object of attaining co-operation in malaria control. This body has been of great service, but in my opinion there are two grave defects in its constitution, namely, (*i*) it is too large, and therefore unwieldy, and (*ii*) in certain respects it is not strong enough, for it includes no representatives from either of the Railways who have control over expenditure.

The Committee should consist primarily of individuals who have the power to give orders to the Executive Engineers concerned to carry out necessary measures of malaria prevention.

* This remark applies not only to Bombay, but to every town in India which is provided with a piped water supply.

I recommend that the Malaria Advisory Committee shall be reconstituted, and shall consist in future of the following members :—

The President of the Corporation.
The Municipal Commissioner.
The Executive Health Officer.
The Chairman of the Port Trust.
The Chief Officer of the City Improvement Trust.
The Chairman of the Development Directorate.
A Representative of the Mill-owners' Association.
The A. D. M. S., Bombay Brigade.
The Agent of the B. B. & C. I. Railway.
The Agent of the G. I. P. Railway.

It is very important that in the event of any of the above named Officers being unable to attend a meeting of the Committee, a responsible officer should be deputed to attend in his place. At one of the meetings of the present Advisory Committee held during the progress of this inquiry neither of the Railways was represented.

The Committee above suggested would constitute an exceedingly powerful body, and its recommendations could not fail to carry great weight. Every authority in Bombay would be represented by its Chief Officer, and the numbers of the Committee would not be so large as to make it unwieldy. The Special Malaria Officer would meet the Committee from time to time, and would lay before it all matters of urgency with regard to malaria control.

I feel convinced that the creation of this body will be one of the most important steps towards the eradication of malaria in Bombay, a result which can only be attained by active and loyal co-operation on the part of all the authorities concerned.

CHAPTER XI

SUMMARY

The results of the present inquiry have confirmed in every respect the conclusions formed by Bentley in 1911 as to the causation of malaria in Bombay.

At the present time the disease constitutes a serious cause of sickness and loss of revenue to the City. Its incidence has increased rather than diminished during the past 30 years, for whilst it is less prevalent than formerly in the southern portion of the City it has now become much more widely diffused, **the most severely affected parts of the island at present being the areas in which most of the mills are situated.** The Mills, Railways and in certain cases the Municipality itself are directly responsible for a large part of the malaria existing amongst their employees.

There is no natural malaria in the island, the breeding-places of *Anopheles stephensi*, the mosquito responsible for the transmission of the disease in Bombay, being exclusively man-made. These breeding-places are probably at least as numerous as they were at the time of Bentley's investigation, because (*i*) only a comparatively small proportion of those then existing have been eliminated, and (*ii*) a large number of others, notably imperfectly protected cisterns, garden tanks and fountains, and breeding-places formed in connection with modern methods of building construction, have been created.

The solution of the problem lies in the prosecution of a systematic campaign having for its object the elimination of all potential breeding-places of *A. stephensi*, particularly those which are of a permanent nature, and which thus permit this mosquito to continue breeding throughout the year. The measures to be adopted have been set out in detail in the body of this report. **The most important are the permanent closure of every well in the island, the rendering of every cistern mosquito-proof, the abolition of all garden tanks and tubs, and the regular weekly treatment of mill-ponds with paris green.**

The success of the scheme depends mainly on the following factors :—

(i) The placing of the whole of Bombay for the purpose of malaria control directly under the Special Malaria Officer of the Municipality, who will have no other duties whatsoever.

(ii) The reconstitution of the present Malaria Advisory Committee.

(iii) The provision of effective legislation to enforce the necessary measures, which will allow no opportunities for evasion or delay.

(iv) This legislation to apply to Railways, Government Departments and to all other public or private bodies in Bombay, as well as to private individuals.

(v) Active co-operation in the carrying out of preventive measures on the part of the Officers controlling the Railways, Government

Departments and other public bodies, and on the part of the Municipality itself. Without this co-operation no anti-malarial scheme in Bombay can possibly succeed.

The adoption of the scheme will lessen the work of the Malaria Department to a great extent, and it is hoped that without any considerable increase of personnel they will be able to carry out their duties efficiently, a task which is impossible under the present conditions.

I feel confident that endemic malaria in Bombay can be brought under complete control; indeed, I see no reason why it should not be eradicated completely from the island. **But it is quite certain that this result will not be achieved without the whole-hearted adoption of radical and systematic measures.**

Malaria represents a constant drain upon the resources of Bombay, and the money spent on anti-malarial measures at the present time is very largely wasted, because it is impossible under existing conditions to strike at the root of the evil. The scheme now put forward does not involve any great expenditure, and it can be carried out at a cost considerably less than the amount lost annually by the City from interference with labour and provision of medical aid to those suffering from the disease. Indeed, the money so spent may justly be looked upon as a very profitable investment, apart altogether from humanitarian considerations.

If conditions are allowed to continue as they are at the present time, not only will the expenditure of time and money involved in the present inquiry be wasted, but Bombay will be exposed at any time when economic and other conditions become especially favourable, to the risks of outbreaks of malaria as serious as, and possibly more serious than those which have occurred in the past.

A feature of malaria in Bombay, as elsewhere, is that it tends to occur as it were in waves, a few years of bad malaria (as in 1907-1912, and 1919-1925) alternating with periods of diminished prevalence. At the present time the disease appears to be on the decline, and therefore it is a most favourable moment to carry out an intensive campaign of prevention. For this reason it is of the greatest importance that the necessary machinery for carrying out the measures detailed in this report shall be put in motion with the least possible delay.

Finally, I would urge that the lessons of the past with regard to the disastrous results of adopting half-measures of malaria control may not be forgotten, and that no part of this scheme, every detail of which I regard as of importance for the attainment of complete success, may be set aside without the most earnest consideration.

Note on Urban Malaria in India

I wish to draw attention to the fact that *Anopheles stephensi*, which occupies in India the position held by *A. bifurcatus* in Palestine of being the principal transmitter of urban malaria, occurs throughout this country, and that it will breed in unprotected cisterns not only

in Bombay but in every town in India provided with a piped water supply. It is of great importance that this fact should be widely known, especially to all hydraulic engineers; otherwise there is grave danger that the introduction of a piped water supply into a town will be followed by an increased incidence of malaria, just as is the case when irrigation projects are not accompanied by adequate schemes of drainage.

A considerable amount of unnecessary sickness and loss of life would be prevented if all engineers proceeding to the tropics were required to attend a short course of instruction in the first principles of tropical sanitation before taking up their duties.

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Appendix A

TABLE I

CLIMATIC DATA FOR BOMBAY (COLABA)

Temperature (in degrees Fahrenheit)

	Monthly normals derived from 24 hourly tabulations of dry bulb thermograms (1873-1920)	Means for observation hours (1873-1920)			Normal monthly temperatures		
		6 a.m.	2 p.m.	10 p.m.	Maximum	Minimum	Range
January ..	73·9	69·4	79·8	72·8	82·5	67·9	14·6
February ..	74·4	69·8	79·9	73·3	82·8	68·4	14·4
March ..	78·2	74·9	82·9	77·1	85·7	73·2	12·5
April ..	81·7	77·9	86·0	80·4	88·6	77·5	11·1
May ..	84·3	81·3	88·3	82·8	90·8	80·7	10·1
June ..	83·0	81·1	85·5	82·1	88·0	79·7	8·3
July ..	80·9	79·7	82·7	80·4	84·6	77·7	6·9
August ..	80·1	78·7	82·1	79·5	84·2	77·1	7·1
September ..	80·0	77·9	82·8	79·3	84·7	76·7	8·0
October ..	81·0	77·5	85·5	79·8	87·8	76·7	11·1
November ..	79·0	74·6	84·9	77·6	87·2	73·5	13·7
December ..	75·7	71·2	82·1	70·3	84·7	70·0	14·7
Year ..	79·3	76·0	83·5	78·2	86·0	74·9	11·1

Appendix A

TABLE II

Climatic Data for Bombay (Colaba)

Precipitation, Moisture, Wind

	Rainfall 1847-1920			Extent of cloud whole sky = 10	Moisture							
					Pressure of vapour				Relative Humidity of the air			
	Average amount	Greatest monthly and annual amount	Average number of rainy days*		6 a.m.	2 p.m.	10 p.m.	Mean	6 a.m.	2 p.m.	10 p.m.	Mean
	"	"			"	"	"	"	%	%	%	%
January ..	0·09	2·99	0·2	1·3	·530	·586	·583	·571	73	57	71	68
February ..	0·06	1·68	0·1	1·3	·544	·612	·592	·581	74	59	71	68
March ..	0·04	1·46	0·1	1·8	·670	·720	·703	·696	80	64	76	72
April ..	0·04	1·57	0·1	3·1	·777	·819	·808	·800	81	66	78	74
May ..	0·68	11·17	0·7	4·0	·847	·881	·869	·864	79	66	78	74
June ..	19·68	43·45	14·7	7·6	·892	·932	·907	·910	84	76	83	81
July ..	23·95	59·26	21·8	8·9	·876	·914	·886	·891	86	82	85	85
August ..	13·21	36·56	19·2	8·9	·847	·886	·855	·862	86	81	85	84
September ..	10·29	31·51	13·0	7·3	·847	·877	·843	·852	88	78	84	83
October ..	2·06	16·11	2·5	3·6	·800	·848	·831	·829	84	68	81	78
November ..	0·39	5·53	0·7	1·7	·657	·690	·705	·692	77	58	75	70
December ..	0·05	1·14	0·2	1·7	·561	·596	·612	·601	73	54	72	68
Year ..	70·54	114·89	73·3	4·3	·737	·780	·766	·762	80	67	78	75

	Wind								Mean Velocity (M. P. H.)
	Resultant component (in miles per hour)								
	7 to 8 a.m.		3 to 4 p.m.		10 to 11 p.m.		Mean		
January ..	3·1N	4·1E	6·0N	6·9W	4·7N	0·5W	4·6N	0·7W	6·9
February ..	3·0N	2·9E	6·8N	8·1W	4·5N	1·1W	4·9N	2·1W	7·3
March ..	2·2N	1·8E	6·2N	9·5W	3·6N	2·8W	4·1N	3·6W	7·5
April ..	1·2N	0·5E	4·9N	10·4W	3·2N	4·0W	2·9N	4·6W	7·4
May ..	0·2S	1·9W	1·4N	9·7W	0·5N	4·5W	0·5N	5·3W	7·1
June ..	3·7S	3·9W	3·8S	8·4W	4·4S	5·3W	4·0S	5·9W	10·3
July ..	3·4S	10·2W	3·0S	11·6W	3·8S	10·1W	3·4S	10·7W	12·3
August ..	1·9S	8·9W	1·2S	10·8W	2·0S	8·9W	1·8S	9·6W	10·6
September ..	0·7S	1·9W	1·6N	8·1W	0·2N	4·1W	0·3N	4·7W	7·3
October ..	1·0N	3·9E	3·9N	6·6W	2·0N	0·1E	2·2N	0·6W	6·3
November ..	2·4N	6·0E	4·5N	5·1W	3·4N	0·8E	3·4N	0·8E	6·6
December ..	2·9N	6·1E	4·9N	6·0W	4·2N	0·5E	4·0N	0·7E	6·7
Year ..	0·5N	0·1W	2·7N	8·4W	1·3N	3·3W	1·5N	3·9W	8·0

*A rainy day is a day on which 0·10" or more of rain is recorded.

Appendix A

TABLE III

RAINFALL RECORDED AT BOMBAY (COLABA)

Five day period	Five day sums					Five day period	Five day sums				
	1916	1917	1918	1919	1920		1916	1917	1918	1919	1920
	"	"	"	"	"		"	"	"	"	"
1	..	..	..	..	0·07	38	5·39	0·31	0·47	1·48	12·33
2	..	..	..	..	0·92	39	7·98	0·54	0·02	0·92	2·76
3	..	..	..	..	..	40	1·09	2·31	0·14	1·39	0·86
4	..	..	..	..	..	41	0·69	7·47	0·84	2·95	1·02
5	..	..	..	..	..	42	6·94	1·17	0·48	9·19	1·18
6	..	..	..	0·11	..	43	14·45	0·56	0·74	1·10	2·29
7	..	1·68	..	..	0·04	44	1·97	3·44	0·34	1·16	0·92
8	..	..	..	..	0·29	45	0·80	2·82	0·55	0·99	0·32
9	..	..	..	..	..	46	2·61	1·23	1·29	2·40	0·11
10	..	..	..	..	..	47	0·55	7·60	1·62	1·74	0·70
11	..	..	..	..	..	48	0·51	11·80	0·28	3·02	0·88
12	..	..	..	..	..	49	0·16	9·39	0·93	2·11	0·27
13	..	..	..	..	..	50	1·71	5·96	0·07	0·74	0·74
14	..	..	..	..	..	51	5·56	0·63	0·95	0·04	1·92
15	..	..	1·35	..	..	52	2·48	0·70	0·16	1·03	0·71
16	..	..	..	..	..	53	3·37	0·01	0·40	0·34	0·44
17	..	..	0·11	..	..	54	1·43	1·05	0·62	4·45	0·16
18	..	..	..	..	..	55	0·13	6·26	..	2·07	..
19	0·04	..	..	..	..	56	0·65	12·98	..	..	0·33
20	..	..	..	..	..	57	..	0·13	..	..	..
21	..	..	..	..	..	58	1·55	0·04	..	..	..
22	..	..	..	..	..	59	0·39	0·65	..	..	0·01
23	..	..	..	..	..	60	1·52	2·11	..	0·18	..
24	..	..	..	..	..	61	0·59	..	..	..	..
25	..	0·08	..	..	..	62	..	..	..	0·18	..
26	..	0·16	0·03	..	..	63	0·72	..	0·09	..	..
27	..	..	0·19	..	..	64	..	..	..	..	..
28	..	..	0·01	..	..	65	..	..	..	..	..
29	..	..	0·81	..	..	66	..	..	..	..	..
30	0·07	0·64	9·78	..	..	67	..	..	..	..	..
31	1·76	0·01	1·67	0·41	..	68	..	..	..	..	..
32	11·50	2·68	0·84	13·80	0·38	69	..	..	..	..	..
33	1·52	5·23	..	0·28	6·54	70	..	..	..	..	..
34	3·00	1·96	5·66	0·13	0·33	71	..	..	..	..	..
35	3·45	1·62	2·73	0·13	0·33	72	..	..	..	..	..
36	2·32	3·43	0·10	1·47	0·60	73	..	..	..	..	..
37	0·05	1·11	2·27	15·31	3·52						

Appendix A

TABLE IV

NUMBER OF DAYS IN EACH MONTH IN WHICH RAINFALL WAS 0·10″ OR MORE

Month	1921	1922	1923	1924	1925
January	..	..	..	..	..
February	..	..	..	..	..
March	..	..	..	..	..
April	..	..	..	..	..
May	..	..	..	..	4
June	13	17	8	11	20
July	24	27	24	23	21
August	22	17	17	15	15
September	19	20	17	20	7
October	..	2	..	..	1
November	..	..	..	1	2
December	..	1	..	..	..

Appendix A

TABLE V

MONTHLY MEANS OF MAXIMUM AND MINIMUM TEMPERATURES AND HUMIDITY

	1921			1922			1923			1924			1925		
	Monthly mean Maximum Temperature	Monthly mean Minimum Temperature	Monthly mean Humidity	Monthly mean Maximum Temperature	Monthly mean Minimum Temperature	Monthly mean Humidity	Monthly mean Maximum Temperature	Monthly mean Minimum Temperature	Monthly mean Humidity	Monthly mean Maximum Temperature	Monthly mean Minimum Temperature	Monthly mean Humidity	Monthly mean Maximum Temperature	Monthly mean Minimum Temperature	Monthly mean Humidity
	°	°	%	°	°	%	°	°	%	°	°	%	°	°	%
January	83·9	67·9	64	83·7	68·2	68	84·5	69·0	67	82·7	68·2	71	80·9	65·5	65
February	84·4	68·8	67	84·9	70·2	67	82·5	68·6	66	83·3	69·4	70	81·1	65·5	65
March	87·9	74·1	71	87·4	72·8	69	88·2	75·0	72	89·5	75·7	71	89·5	74·4	67
April	90·9	78·9	75	90·5	78·6	75	90·0	77·7	72	91·5	79·4	72	91·0	79·6	74
May	92·5	81·5	70	92·1	81·3	71	90·9	80·6	72	92·9	81·6	71	91·8	81·7	73
June	89·0	80·5	79	87·8	80·0	81	90·4	81·7	77	90·4	81·3	76	86·7	78·7	83
July	84·3	77·5	85	83·8	77·3	85	83·8	77·6	88	85·1	79·1	85	85·8	78·6	83
August	83·8	77·2	84	83·7	77·0	83	84·4	77·5	85	85·3	78·5	83	85·4	78·1	81
September	84·0	76·6	83	84·1	76·4	83	85·0	76·8	83	85·3	77·0	86	86·9	77·6	81
October	89·3	77·3	75	89·6	76·7	76	89·3	77·1	77	87·6	76·2	76	91·7	79·6	74
November	87·5	73·1	69	88·5	75·3	69	86·4	72·4	72	86·5	72·4	68	90·5	77·1	68
December	85·2	70·7	68	84·3	69·6	66	86·0	71·2	68	84·9	70·6	72	86·9	73·0	68

Appendix B

Population and Density per acre by Sections

	Section	Population, 1906	Density per acre, 1906	Population, 1921	Density per acre, 1921	Estimated population, 1927
A	Upper Colaba	3,775	20	3,747	23·94	3,714
	Middle and Lower Colaba ..	15,310	54	20,048	71·67	20,103
	Fort, South	3,904	30	4,153	31·20	4,547
	Fort, North	28,778	214	30,921	194·86	34,434
	Esplanade	11,015	16	15,571	21·94	15,434
B	Chakla	29,362	569	22,996	489·07	22,794
	Mandvi	38,158	232	38,612	206·12	41,656
	Umarkhadi	53,610	509	47,218	469·18	47,768
	Dongri	32,633	114	20,749	68·56	20,568
C	Market	35,305	396	35,080	411·69	37,842
	Dhobi Talao	36,594	367	42,171	356·57	43,082
	Fanaswadi	29,240	233	30,105	305·82	31,530
	Bhuleshwar	38,129	503	34,622	471·30	34,317
	Kumbharwada	32,784	712	32,481	736·86	35,181
	Khara Talao	26,935	647	23,925	581·55	24,308
D	Khetwadi	33,579	197	39,615	255·58	44,070
	Girgaum	28,449	228	36,003	320·31	38,953
	Chowpatti	13,033	117	14,260	131·16	15,027
	Walkeshwar	12,685	23	18,111	30·70	22,623
	Mahalakshmi	24,650	38	38,040	57·77	45,046
E	Tardeo	28,193	123	31,986	213·44	34,349
	Kamathipura	36,484	552	44,585	714·05	49,091
	1st Nagpada	3,335	113	7,645	260·21	8,350
	2nd Nagpada	22,016	647	23,103	699·03	23,779
	Byculla	76,280	149	91,340	160·93	100,540
	Tarwadi	26,278	55	40,717	81·63	48,047
	Mazagaon	30,872	48	36,773	34·19	40,641
F	Parel	46,960	85	60,196	107·25	68,871
	Sewri	15,985	36	28,645	49·58	34,383
	Sion	30,515	7	56,444	15·86	72,054
G	Mahim	31,178	24	48,130	31·85	58,735
	Worli	69,488	38	119,790	52·69	137,607
	Harbour, Docks, Railways, and Homeless ..	32,440	..	38,132	..	37,797
	Total ..	977,822	68	1,175,914	78·05	1,298,708

Appendix C

STATEMENT SHOWING THE AVERAGE NUMBER OF SEERS OF WHEAT, JAWAR, BAJRI AND RICE PURCHASABLE FOR ONE RUPEE IN BOMBAY CITY IN EACH YEAR FROM 1912 ONWARDS

Year	Wheat		Jawar		Bajri		Rice	
	S.	ch.	S.	ch.	S.	ch.	S.	ch.
1912	6	14	9	12	9	11	7	8
1913	7	1	9	12	10	10	7	8
1914	6	13	9	5	9	4	7	4
1915	5	8	10	9	9	1	7	3
1916	7	1	11	6	8	11	6	15
1917	6	11	9	11	8	4	6	15
1918	4	5	4	10	4	10	5	5
1919	4	1	4	2	4	3	5	4
1920	4	6	5	5	5	12	5	5
1921	4	1	5	2	4	6	5	6
1922	4	8	7	4	5	10	5	7
1923	5	10	8	0	7	5	5	11
1924	5	7	7	11	7	6	5	5
1925	5	2	7	5	6	11	5	6
1926	5	3	7	2	6	9	5	6
1927	5	4	7	0	6	10	5	7

Note.—Average annual prices for the years 1912-1921 are those given in "Prices and Wages in India, 1923"; the average annual prices for the years 1922-1927 are arrived at by striking the averages for the quotations in the fortnightly returns of retail prices published in the *Bombay Government Gazette.*

Appendix D

TABLE I

CASES OF MALARIA AND "FEVER NOT DEFINED" TREATED AT MUNICIPAL DISPENSARIES BY MONTHS, 1922-1927

——	1922	1923	1924	1925	1926	1927
January ..	1,251	1,163	1,177	1,292	1,690	1,037
February ..	838	1,010	987	953	1,140	941
March ..	974	938	860	1,143	1,235	957
April ..	1,018	1,218	831	1,181	1,280	1,074
May ..	1,089	1,161	1,033	1,326	1,267	1,037
June ..	1,177	910	998	1,169	1,192	957
July ..	1,474	1,097	1,414	1,836	1,378	1,504
August ..	1,854	1,531	2,265	2,855	1,920	1,721
September ..	1,953	1,845	3,126	4,630	2,663	2,012
October ..	2,742	2,270	4,152	5,814	3,010	2,635
November ..	1,977	1,673	2,868	3,401	2,473	2,426
December ..	1,540	1,288	1,585	2,438	1,420	1,387
Total fever cases treated ..	17,887	16,104	21,296	28,038	20,668	17,688
Total new cases treated ..	71,020	69,036	75,577	78,665	71,921	68,887
Percentage of fever cases to total new cases ..	25·18	23·32	28·17	35·64	28·74	25·67

Appendix D

TABLE II

ADMISSIONS FOR MALARIA IN DIFFERENT INSTITUTIONS, 1922-1927

—	1922	1923	1924	1925	1926	1927
Colaba B. M. H.	440	227	160	139	175	128
Marine Lines I. M. H. ..	353	165	291	251	186	54
St. George's Hospital ..	1,537	1,065	1,147	1,238	1,078	509
Goculdas Tejpal Hospital ..	859	1,899	2,261	3,202	2,669	1,715
Cama and Albless Hospital ..	259	185	304	282	184	125
Sir J. J. Hospital	1,789	2,598	2,434	4,767	4,693	3,452
Northcote Police Hospital ..	4,194	4,228	3,934	5,321	3,499	2,044
G. I. P. Railway Infirmary ..	4,389	3,179	2,675	3,949	3,373	2,551
Dr. Masina's Hospital ..	254	344	364	330	252	116
Adam's Wylie Hospital. ..	..	..	..	687	1,036	153
Yamunabai Nair Hospital ..	..	..	..	..	545	83

Appendix D

TABLE III

TOTAL DEATHS FROM MALARIA AND AGUE AND REMITTENT FEVER, 1911-1927

Year	Deaths from Malaria	Deaths from Ague and Remittent Fever	Total deaths Malaria and Ague and Remittent Fever
1911	334	....	....
1912	360	3,070	3,430
1913	261	2,624	2,885
1914	213	2,517	2,730
1915	208	1,774	1,982
1916	238	1,735	1,973
1917	263	2,012	2,275
1918	200	4,219	4,419
1919	262	5,071	5,333
1920	311	3,216	3,527
1921	545	4,234	4,779
1922	485	2,703	3,188
1923	403	2,692	3,095
1924	488	2,679	3,167
1925	581	2,337	2,918
1926	635	2,004	2,639
1927	365	1,633	1,998

Appendix D

TABLE IV

DEATHS BY MONTHS FROM MALARIA (INCLUDING AGUE AND REMITTENT FEVER)

—	1918	1919	1920	1921	1922	1923	1924	1925	1926	1927
January	262	445	379	423	317	259	315	286	238	189
February	236	314	344	430	295	249	270	243	183	192
March	315	350	272	538	325	334	249	272	211	182
April	336	762	299	546	265	280	219	256	180	165
May	283	636	280	380	219	276	178	251	183	158
June	247	344	205	266	209	237	165	183	173	118
July	403	367	224	315	204	181	155	190	214	133
August	206	426	244	381	239	230	259	213	258	213
September	838	431	293	404	240	259	304	247	269	172
October	680	486	357	432	325	273	412	319	281	148
November	266	388	300	351	282	221	357	241	246	169
December	347	384	330	313	268	296	284	217	203	159
	4,419	5,333	3,527	4,779	3,188	3,095	3,167	2,918	2,639	1,998

Appendix D

TABLE V

RATIO PER 1,000 OF STRENGTH OF ADMISSIONS FOR MALARIA AMONGST BRITISH AND INDIAN TROOPS STATIONED IN BOMBAY

Year	British Troops		Indian Troops	
	Number of cases	Ratio per 1,000	Number of cases	Ratio per 1,000
1896	107	88	257	205
1897	268	238	249	180
1898	168	140	303	250
1899	227	179	271	220
1900	173	149	318	258
1901	241	194	522	413
1902	154	116	329	282
1903	205	154	391	300
1904	142	110	323	321
1905	233	184	271	376
1906	256	228	261	471
1907	240	227	232	396
1908	392	340	330	509
1909	304	288	235	330
1910-13	Not available.		Not available.	
1914	193	155	Do.	
1915	69	147	Do.	
1916	224	213	Do.	
1917	809	344	Do.	
1918	1,192	517	Do.	
1919	710	379	Do.	
1920	916	605	Do.	
1921	1,101	973	Do.	
1922	350	418	Do.	
1923	140	169	162	265
1924	160	223	133	216
1925	144	226	184	366
1926	175	216	134	235
1927	128	150	40	81

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TABLE VI

RATIO PER THOUSAND OF STRENGTH OF CASES TREATED FOR MALARIA AMONGST THE POLICE STATIONED IN BOMBAY, 1921-1927

Year	Sanctioned strength of Force	Total Cases treated for Malaria	Ratio per 1,000 of strength
1921	3,149	4,900	1,556
1922	3,247	4,462	1,374
1923	3,543	4,288	1,210
1924	3,413	4,298	1,259
1925	3,495	4,797	1,372
1926	3,495	3,105	889*
1927	3,478	1,845	534*

* *Note.*—In the Annual Reports on the Police of the City of Bombay for the years 1926 and 1927 the decrease in the number of malaria cases is attributed to the giving of a six weeks' course of treatment with Quinine Mixture to all men who have been admitted for this disease after their discharge from Hospital, and also to the fact that the Armed Police (448 in number) have been transferred to new lines at Naigaum.

It must be pointed out however that figures available from other sources show that this decrease in the incidence of the disease has been general throughout Bombay, though possibly not to such a great extent.

Appendix E

TABLE I

TABLE SHOWING RESULTS OF SPLEEN AND BLOOD EXAMINATIONS ("RANDOM SAMPLING")

Ward	Section	Locality	Number of Children Examined	Percentage with Palpable Spleen	Percentage showing Malaria Parasites in Blood	Percentage showing evidence of Malarial Infection
A.	Upper Colaba ..	Reclamation Labour Camps ..	100*	17	20	22
	Middle and Lower Colaba.	Gun Carriage Street ..	35	2	5	5
		Bora Street	22			
		Colaba Land Mill	43	23	19	28
	Fort North ..	Cochin Street	72	21	14	21
		Goa Street	14	..	..	..
	Esplanade ..	Paltan Road	100	3	4	5
		St. George's Hospital ..	36	12	..	..
		G. I. P. Yard, Victoria Terminus.	23			
		B. B. & C. I. Yard, Carnac Bunder	36			
B.	Mandvi ..	Dongri Street	100	14	14	22
	Umarkhadi ..	Imamwada Street	100	9	7	11
	Dongri ..	Valpakadi (Municipal Chawls) ..	100	41	31	45
C.	Market ..	Princess Street	34	3	11	12
		Takwadi Street	33			
		Picket Road	33			
	Dhobi Talao ..	Chandanwadi Street ..	100	6	8	11
	Fanaswadi ..	Tadwadi Street	67	11	8	12
		Fanaswadi Street	33			
	Bhuleshwar ..	2nd Popalwadi Street ..	44	12	14	17
		2nd Bholwada Street ..	56			
	Khara Talao ..	Khoja Street	100	8	7	10
	Kumbharwada ..	Northbrook Gardens ..	100	10	15	17
D.	Khetwadi ..	Falkland Road	65	0	6	6
		Khawa Lane	35			
	Girgaum ..	Girgaum Road	59	8	28	32
		Mugbhat Road	41			
	Chowpati ..	Gamdevi Road	100	31	37	41
	Walkeshwar ..	Hindu Orphanage	41	16	24	26
		Old Bodyguard Stables ..	23			
		Gowalia Tank Road ..	36			

RESULTS OF SPLEEN AND BLOOD EXAMINATIONS—*contd.*

Ward	Section	Locality	Number of Children Examined	Percentage with Palpable Spleen	Percentage showing Malaria Parasites in Blood	Percentage showing evidence of Malarial Infection
	Mahalakshmi ..	Clerk Road, Tardeo Flats ..	100	39	36	53
		B. B. & C. I. Chawls, Bellasis Road	48	11	..	..
		Ganjawala Chawls, Bellasis Road	100			
E.	Mazagon ..	Wadi Bunder Road ..	100	12	8	13
	Tarwadi ..	Nesbit Road	100	29	29	32
		Mahomedan Orphanage ..	21	35	16	40
		Hindu Orphanage	39			
	2nd Nagpada ..	Tank Road	100	8	7	8
	Kamathipura ..	Stable Street	100	8	5	8
	Tardeo ..	Foras Road	100	27	26	33
	Byculla ..	Agripada Street	100	21	23	26
		B. B. & C. I. Chawls, Lamington Road	33	15	..	..
F	Parel ..	Chamar Baug Road ..	100	21	6	22
		Parel Village	100	10	..	..
		Curry Road	100	45	34	49
	Sewri ..	Jackeria Bunder	100	2	2	4
		Bhoiwada Village	100	2	..	..
	Sion ..	Dadar Road	100	13	7	14
		Sion Road	100	3	1	4
G.	Mahim ..	Dharavi Village	100	2	4	5
		Mori Road	20	6	1	6
		Police Lines, Mahim Village ..	35			
		Lady Jamshedji Road ..	20			
	Worli ..	DeLisle Road, B. D. T. Chawls ..	100	2	10	10
		Worli Road, B. D. T. Chawls ..	100	21	14	30
		Elphinstone Mill Area ..	58	36	22	39
		DeLisle Road, Municipal Chawls	42	60	38	69
		DeLisle, Road, B. B. & C. I. Chawls	40	55	..	..
		Carrol Road, B. B. & C. I. Chawls	74	42	..	..
		Dadar Joint Yard, B. B. & C. I. .	19	10	..	..
		Worli Village	100	11	..	..

Note.—Out of 511 positive blood films, Malignant Tertian parasites were found in 66 per cent., Benign Tertian in 25 per cent. and Quartan in 10 per cent. There were 13 mixed infections.

Appendix E

TABLE II

Results of Spleen Census of Municipal School Children

Ward and Section	Name of School	Number examined	Number showing enlarged spleen	Per cent. showing enlarged spleen	Remarks
Ward G					
MAHIM ..	Dharavi Branch Marathi Boys..	46	1	2·2	1 *ex* Bombay.
	Dharavi Koliwada Marathi Boys.	67	1	1·5	
	Dharavi Marathi Boys ..	121	1	0·8	
	Dharavi Tamil	41	0	..	
	Mori Road Marathi Boys ..	41	3	7·3	
	Mahim Bazaar Road Gujarati ..	30	0	..	
	Mahim Bazaar Road Marathi Boys.	39	2	5·1	1 Worli.
	Upper Mahim Marathi Boys ..	139	4	2·9	
	Mahim Chunabhati Marathi Boys	150	1	0·6	
	Upper Mahim Marathi Girls ..	127	0	..	
	Cadell Cross Road Marathi Boys.	46	2	4·3	
	Mahim Gujarati Boys ..	44	2	4·5	
	Mahim Gujarati Girls ..	34	1	2·9	
	Gopi Tank Marathi Boys ..	157	4	2·5	
	Gopi Tank Marathi Girls ..	77	2	2·6	
	Lady Hardinge Road Gujarati Boys.	51	6	11·8	
	Lady Hardinge Road Marathi ..	61	2	3·3	
	Cadell Road No. 2 Marathi Boys.	99	1	1·0	
	Lady Jamshedji Road Marathi Boys.	401	12	3·0	1 *ex* Bombay.
	Lady Jamshedji Road Gujarati.	97	5	5·1	1 Parel, 1 Tardeo.
	Lower Mahim Marathi Girls ..	175	2	1·1	
WORLI ..	Worli Koliwada Boys ..	130	5	3·8	
	Worli Koliwada Girls ..	53	1	1·9	
	Lower Mahim Marathi Boys ..	127	2	1·6	
	Dadar Kumbharwada Marathi Girls.	303	3	1·0	1 *ex* Bombay.
	Parbhadevi Road Marathi Boys.	173	5	2·9	
	Parbhadevi Road Marathi Girls.	100	7	7·0	
	Dadar New Bawanishankar Road Marathi Boys.	171	8	4·6	
	Parbhadevi Road Marathi ..	103	26	25·2	
	Parbhadevi Gujarati ..	37	23	62·2	
	DeLisle Road No. 2 Urdu ..	59	22	37·3	1 *ex* Bombay.
	DeLisle Road Marathi Boys ..	187	57	30·5	
	Elphinstone Road Gujarati ..	78	18	23·1	1 *ex* Bombay.

RESULTS OF SPLEEN CENSUS OF MUNICIPAL SCHOOL CHILDREN—*contd.*

Ward and Section	Name of School	Number examined	Number showing enlarged spleen	Per cent. showing enlarged spleen	Remarks
WORLI—*contd.*	Elphinstone Bridge Marathi Boys.	125	26	20·8	1 *ex* Bombay.
	Elphinstone Bridge Marathi Girls.	83	14	16·8	
	North Worli Marathi ..	195	71	36·4	1 *ex* Bombay.
	Worli Marathi	79	20	26·2	
	Fergusson Road Marathi Boys ..	210	28	13·3	
	Fergusson Road Marathi Girls ..	56	2	3·6	
	Lower Parel Station Road Marathi Boys.	138	24	17·4	
	Lower Parel Gujarati Boys ..	129	32	24·8	
	Lower Parel Gujarati Girls ..	85	18	21·2	
	Lower Parel Urdu	41	9	21·9	
	Lower Parel Marathi Girls ..	63	4	6·3	
	Sun Mill Road Marathi Boys ..	167	17	10·2	
	Curry Road Marathi Boys ..	342	32	9·4	
	Curry Road Marathi Girls ..	67	2	3·0	
	Arthur Road Urdu ..	28,	4	14·3	
	DeLisle Road B. D. D. Marathi.	105	10	9·5	1 *ex* Bombay.
	DeLisle Road L. P. Marathi Boys.	52	2	3·8	
	Clerk Road Marathi ..	63	4	6·4	
	Jacob Circle Urdu Boys ..	26	4	15·4	
	Jacob Circle Urdu Girls ..	22	0	..	
	Jacob Circle Gujarati Boys ..	34	6	17·7	
Ward F					
SION ..	Sion Marathi Boys	111	1	0·9	
	Sion Marathi Girls	21	0	..	
	Matunga Labour Camp Marathi.	54	1	1·8	
	Matunga Gujarati Girls ..	65	1	1·5	
	Matunga Station Road Marathi Boys.	159	2	1·2	
	Matunga Station Road Marathi Girls.	92	0	..	
	Matunga Model Gujarati Boys...	173	8	4·6	
	Matunga Road Marathi Boys ..	106	3	2·8	
	Wadala Marathi Boys ..	167	3	1·8	1 *ex* Bombay.
	Wadala Marathi Girls ..	63	1	1·6	
	Naigaum Gujarati	41	3	7·3	
	Dadar Urdu	43	3	6·9	
	Dadar Marathi Boys ..	103	6	5·8	

RESULTS OF SPLEEN CENSUS OF MUNICIPAL SCHOOL CHILDREN—*contd.*

Ward and Section	Name of School	Number examined	Number showing enlarged spleen	Per cent. showing enlarged spleen	Remarks
SION—*contd.* ..	Dadar Cross Road Marathi Girls.	93	2	2·1	
	Dadar Cross Road Gujarati	36	2	5·5	
	Dadar Main Road Gujarati ..	34	3	8·8	
	Dadar Stable Marathi ..	29	0	..	
	Naigaum No. 1 Marathi Boys ..	88	7	7·9	
	Naigaum Marathi Girls ..	40	3	7·5	
	Naigaum No. 2 Marathi ..	63	5	7·9	
	Parel Bhoiwada Cross Road Marathi Boys.	187	9	4·8	
	Parel Bhoiwada Gujarati ..	63	6	9·5	
	Parel Bhoiwada Marathi Boys ..	188	14	7·4	
	Parel Bhoiwada Marathi Girls ..	74	1	1·4	
SEWRI ..	Sewri Marathi Boys ..	70	0	..	
	Sewri Koliwada Marathi Boys ..	73	0	..	
	Golanji Hill Marathi Boys ..	141	10	7·1	1 Dongri.
	Golanji Hill Marathi Girls ..	55	2	3·6	
	Parel Tank Marathi Boys ..	24	2	8·4	
	South Sewri Marathi Boys ..	76	7	9·2	1 *ex* Bombay.
	Jackeria Bunder Marathi Boys..	72	1	1·4	
PAREL ..	Parel Marathi Boys ..	116	18	15·5	
	Poibavdi Marathi Boys ..	162	14	8·6	
	Poibavdi Marathi Girls ..	124	19	15·3	
	Poibavdi Urdu Boys ..	50	8	16·0	2 *ex* Bombay.
	Poibavdi Urdu Girls ..	27	2	7·4	
	Poibavdi Gujarati Boys ..	129	18	13·9	2 *ex* Bombay.
	Poibavdi Gujarati Girls ..	49	1	2·0	
	Lal Bag Gujarati Boys ..	38	8	21·0	1 *ex* Bombay.
	Lal Bag Gujarati Girls ..	27	2	7·4	
	Suparibag Marathi Boys ..	179	41	22·9	1 *ex* Bombay.
	Suparibag Marathi Girls ..	120	22	18·3	1 *ex* Bombay.
	Lal Bag Marathi Boys ..	134	14	10·8	
	Lal Bag Marathi Girls ..	53	5	9·4	
	Garamkhada Marathi Boys ..	55	5	9·1	
	Kala Chowky Marathi ..	143	33	23·1	1 *ex* Bombay.
	Ambewadi Marathi Boys ..	138	24	17·4	
	Parel Village Marathi Boys ..	184	12	6·5	1 *ex* Bombay.
	Parel Village Marathi Girls ..	114	5	4·4	

RESULTS OF SPLEEN CENSUS OF MUNICIPAL SCHOOL CHILDREN—*contd.*

Ward and Section	Name of School	Number examined	Number showing enlarged spleen	Per cent. showing enlarged spleen.	Remarks
KHETWADI ..	Lamington Road Marathi Boys .	225	19	8·5	
	Lamington Road Marathi Girls .	170	5	2·9	
	Falkland Road Urdu ..	36	0	..	
	West Khetwadi Marathi Boys ..	118	3	2·6	
	West Khetwadi Marathi Girls ..	63	4	6·3	
	Khetwadi Gujarati Girls ..	20	0	..	
	Sandhurst Road Gujarati Boys .	69	7	10·5	
	Angrewadi Marathi Boys ..	120	7	5·8	
	Angrewadi Marathi Girls ..	152	5	3·3	
	Khetwadi A. V. Marathi ..	57	7	12·3	
CHOWPATI ..	Gamdevi Marathi Boys ..	181	32	17·7	
	Gamdevi Marathi Girls ..	91	6	6·6	
	Gamdevi Gujarati Boys' ..	116	7	6·0	2 *ex* Bombay.
	Charni Road Marathi Boys ..	92	9	9·8	
	Charni Road Marathi Girls ..	125	3	2·4	
GIRGAUM ..	Girgaum Gujarati Boys ..	92	6	6·5	1 *ex* Bombay.
	Girgaum Gujarati Girls ..	82	1	1·2	
	Kandewadi Gujarati Boys ..	178	3	1·7	
	Kandewadi Marathi Boys ..	154	4	2·6	
	Kandewadi Marathi Girls ..	118	5	4·3	
	Mugbhat Marathi Girls ..	141	8	5·7	
	Girgaum Marathi Boys ..	210	24	11·4	1 *ex* Bombay. 1 Parel.
	Girgaum Marathi Girls ..	146	5	3·4	1 *ex* Bombay.
	Mugbhat Marathi Boys ..	183	10	5·4	
	S. S. Bengalee Gujarati Girls ..	89	7	7·9	
	South Girgaum Marathi Boys ..	219	15	6·9	
	South Girgaum Marathi Girls ..	168	3	1·8	
	C. P. Tank Gujarati Boys ..	144	15	10·4	3 *ex* Bombay. 1 Mahalakshmi.
	C. P. Tank Gujarati Girls ..	86	3	3·6	1 Mahim.
Ward C					
KUMBHARWADA.	Durgadevi Marathi Girls ..	81	2	2·5	
	Jesharam Premji Gujarati Boys .	101	5	5·0	2 *ex* Bombay.
	Jesharam Premji Gujarati Girls .	57	0	..	
	Parmanand Raja Marathi Boys.	135	1	0·8	

RESULTS OF SPLEEN CENSUS OF MUNICIPAL SCHOOL CHILDREN—*contd.*

Ward and Section	Name of School	Number examined	Number showing enlarged spleen	Per cent. showing enlarged spleen	Remarks
KUMBHARWADA—*contd.*	Nal Bazaar Marathi Boys ..	114	6	4·1	1 *ex* Bombay.
	Islampura Urdu Boys ..	43	2	4·7	
	Islampura Urdu Girls ..	19	0	..	
	Nal Bazaar Gujarati Boys ..	156	13	8·3	
	Nal Bazaar Gujarati Girls ..	74	1	1·4	
	Sutar Lane Marathi Boys ..	122	4	3·3	
	Sutar Lane Marathi Girls ..	55	0	..	
KHARA TALAO.	Chimna Butcher Urdu Girls ..	20	0	..	
	Mutton Street Urdu Boys ..	51	3	6·0	
	Yakub Street Urdu Boys ..	50	8	16·0	
	Yakub Street Urdu Girls ..	70	7	10·0	1 Parel.
	Khara Talao Urdu Boys ..	67	8	12·0	1 *ex* Bombay.
	Khara Talao Urdu Girls ..	34	1	3·0	
	Nal Bazaar Urdu Boys ..	57	3	5·3	
	Nal Bazaar Urdu Girls ..	41	1	2·4	
BHULESHWAR.	Nizampura Urdu Boys ..	119	4	3·4	
	Nizampura Urdu Girls ..	72	1	1·4	
	Ali Umar Urdu Boys ..	38	2	5·3	
	Kika Street Gujarati Boys ..	124	5	4·0	1 *ex* Bombay.
	Kika Street Gujarati Girls ..	129	2	1·6	1 *ex* Bombay.
	Ghogari Mohulla Urdu Boys ..	40	4	10·0	
	Ghogari Mohulla Urdu Girls ..	47	3	6·4	
	Bhendy Bazaar Gujarati Boys ..	75	6	8·0	1 *ex* Bombay.
	Bhuleshwar Gujarati Girls ..	140	6	4·3	
	Bhuleshwar L. P. Gujarati Girls.	86	2	2·3	
	Bhuleshwar A. V. Gujarati Boys.	436	19	4·4	2 *ex* Bombay.
FANASWADI ..	Thakurdwar Marathi Boys ..	208	15	7·2	
	Thakurdwar Marathi Girls ..	165	3	1·8	
	Navi Wadi Marathi Girls ..	176	3	1·7	1 *ex* Bombay.
DHOBI TALAO .	Valibhai Gujarati Girls ..	267	9	3·4	
	Navi Wadi Marathi Boys ..	220	12	5·9	
	Kalbadevi Marathi Boys ..	97	8	8·2	
	Kalbadevi Marathi Girls ..	45	4	9·0	
	N. R. Gujarati Boys ..	261	19	7·3	
	Buddhivardhak Gujarati Boys ..	174	19	10·9	
	Dhobi Talao Marathi ..	62	6	9·7	2 *ex* Bombay.

RESULTS OF SPLEEN CENSUS OF MUNICIPAL SCHOOL CHILDREN—*contd.*

Ward and Section	Name of School	Number examined	Number showing enlarged spleen	Per cent. showing enlarged spleen	Remarks
DHOBI TALAO —*contd.*	Princess Street Urdu Boys ..	38	0	..	
	Princess Street Urdu Girls ..	25	0	..	
	Princess Street Gujarati Boys ..	41	3	7·6	
MARKET ..	Abdul Rehman Street Gujarati Boys.	53	4	7·6	1 *ex* Bombay.
	Kapad Bazaar Gujarati Boys ..	166	9	5·4	1 *ex* Bombay.
	Kapad Bazaar Gujarati Girls ..	102	5	4·9	1 World.
	Kalbadevi Gujarati Girls ..	292	17	6·0	1 *ex* Bombay.
	Lord Harris Gujarati Boys ..	193	16	8·3	2 *ex* Bombay. 2 Parel. 1 Mahalakshmi.
	Princess Street Gujarati Girls ..	114	10	8·7	1 *ex* Bombay.
Ward B					
UMARKHADI ..	Dongri A. V. Marathi Boys ..	172	32	18·6	2 *ex* Bombay. 1 Parel. 1 Byculla.
	Dongri Marathi Girls ..	118	10	8·5	
	Imamwada Urdu Boys ..	80	11	13·7	
	Memonwada Urdu Girls ..	69	5	7·3	
	Nishanpada Urdu	58	4	7·0	
	Murgha Mohulla Urdu Boys ..	15	1	6·6	
	Murgha Mohulla Urdu Girls ..	29	2	7·0	
	J. R. Urdu Boys	43	1	2·3	
	Chhatrisarang Urdu Girls ..	56	1	1·8	
	Kohoja Mohulla Urdu ..	65	8	12·3	1 *ex* Bombay.
DONGRI ..	Nutan Dongri Marathi Boys ..	182	39	21·4	
	Chinchbunder Marathi Boys ..	78	13	16·6	
	J. P. Gujarati Girls.. ..	55	3	5·3	
CHUCKLA ..	Kolsa Mohulla Urdu Boys ..	49	7	14·3	
	Kolsa Mohulla Urdu Girls ..	70	12	17·1	
	Nagdevi Gujarati Girls ..	67	1	1·5	
	Rangari Mohulla Urdu Boys ..	28	0	..	
	Rangari Mohulla Urdu Girls ..	23	0	..	
MANDVI ..	Khoja Mohulla Urdu Girls ..	53	2	3·8	
	Musjid Bunder Gujarati Girls ..	41	2	4·9	
	Peraj Padmasi Gujarati Girls ..	155	16	10·3	1 *ex* Bombay.
	Padmabai Urdu	67	6	9·0	
	Old Bengalipura Urdu Boys ..	44	4	9·1	

RESULTS OF SPLEEN CENSUS OF MUNICIPAL SCHOOL CHILDREN—*concld.*

Ward and Section	Name of School	Number examined	Number showing enlarged spleen	Per cent. showing enlarged spleen	Remarks
MANDVI—*contd.*	Old Bengalipura Urdu Girls ..	17	1	5·9	
	Mandvi Gujarati Boys ..	26	0	..	
	Mandvi Gujarati Girls ..	33	2	6·1	
	Madhavrao Rokde Marathi Boys.	130	11	8·5	2 *ex* Bombay.
	Mandvi Marathi Girls ..	44	0	..	
	Dana Bunder Gujarati Boys ..	24	7	29·2	
Ward A					
ESPLANADE ..	Crawford Market Marathi Boys..	114	13	11·4	
	Lord Harris Marathi Boys ..	179	16	8·4	
	Lord Harris Marathi Girls ..	53	0	..	
FORT NORTH .	Rambhabai Gujarati Girls ..	40	5	12·5	
	Fort Marathi Boys	126	14	11·1	
	Fort Urdu	58	8	13·8	
	Fort Gujarati	43	20	46·5	2 Byculla.
MIDDLE AND LOWER COLABA.	Colaba Urdu	22	3	13·8	1 *ex* Bombay.
	Colaba Marathi Boys ..	200	22	11·0	1 *ex* Bombay.
	Total Number Examined ..	27,647	2,249	8·1	

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